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Signal Translation Through the Ampex Videotape Recorder

By CHARLES E. ANDERSON

Here are described the various operations performed on the video signal as it travels through the Ampex Videotape Recorder. Briefly outlined is the history of each problem and some of the reasons for the solution applied.

The Modulation System

When a standard NTSC monochrome or color signal is fed to the recorder at standard level, the first operation it encounters is in the modulator. The obvious question that comes to mind is, "Why a modulation system?" The reasons for using such a system were covered briefly in an earlier paper.[1] There was not time to develop properly then some of the ideas or to answer all of the obvious questions. It was pointed out in that paper that (a) the use of a carrier system eliminated the problem of reproducing low frequencies from tape, since sidebands generated in the modulation system did not fall much below 500 kc. It also was pointed out (b) that frequency-modulation, in particular, overcame many of the problems inherent in a revolving multi-head device. Unanswered were some questions about what happened to our conventional ideas of frequency modulation (particularly what distortions were generated) when parameters were pushed to the point where the modulating signal approached the carrier in frequency, and the deviation became an appreciable percentage of the carrier. Finally, there was (c) the question of what further distortions were generated by single or vestigial sideband transmission of FM.

All three questions were pragmatically answered in early work by building the equipment and trying it. Fortunately, it worked. As the excitement of early discoveries died, more scientific explanations were sought.

Presented on April 29, 1957, at the Society's Convention at Washington, D. C., by Charles E. Anderson, Ampex Corp., 934 Charter St., Redwood City, Calif.
(This paper first received on May 3, 1957; in final form on August 15, 1958.)

The first question (a) is that of low-frequency response. If 3 mv at 5 mc is considered an adequate output, to still achieve 40 db signal-to-noise, only 3 octaves down from this are possible, giving a lower frequency limit of just under a megacycle. This leaves a usable bandwidth of 4 mc which is adequate for a television image conforming to U.S. standards. The simplest manner in which to use the available spectrum is then to modulate a 5-mc carrier with the 4-mc video signal while utilizing only the lower sidebands.

To take up the second point (b) a complication to a rotating-head method, as used in present recorders, is the chopping of the signal at a 960-c rate. At the present state of the head-building art, it is impossible to build heads that have identical outputs, with the result that each portion of the picture corresponding to one of the four heads will have different contrasts.

The modulation scheme that best handles a fluctuating signal of the variety produced by a rotating, multi-headed scanner is frequency modulation, since the variations in head output can be eliminated by limiting action. If the modulation index is kept smaller than approximately 0.1, only a single pair of sidebands is generated, allowing the information to fit in the allotted space.

Such a statement assumes that a single sideband may be used with frequency modulation, as it is with amplitude modulation.

An apparent answer was found to the questions in point (b) in work by Cambi[2] in which he derived his equations by considering the elementary method for the production of a frequency modulated wave as yielded by a resonant circuit where capacitance or inductance is made periodically variable. Since a multivibrator was used as the oscillator in the Ampex system, there is a logical question as to the validity of applying Cambi's work to this situation.

A means for measuring the amplitudes of the generated sidebands was devised and measurements taken. The results indicate an asymmetrical distribution of the energy, with the higher frequency sidebands having more energy than their lower counterparts. This condition at first seems unfortunate, indeed, for these upper sidebands are those which must be sacrificed if the system is to be squeezed into the limited bandpass available from the tape and heads.

To explore the problem further, a different type of modulator was built and tried. Cambi indicated that a heterodyning process, used to achieve large values of deviations and large values of modulating frequencies with respect to the carrier, would also give the lopsided distribution shown by his theory. If this were true, then a modulator of this type could be compared with a multivibrator, the results observed, and a further check on the validity of the Ampex assumptions be had. Figure 1 is a block diagram of such a modulator. An oscillator operating at 60 mc was modulated by a reactance tube whose input was isolated from the tank circuit by a cathode follower. The output of that oscillator was beat against the output of a second crystal-controlled oscillator operating at 65 mc resulting in a FM carrier having deviations one-fourth of the carrier, with modulating frequencies approaching the carrier.

When the outputs of the two types of modulators were passed through the balance of the system so that each experienced the same frequency sensitive networks, there were no discernible differences in picture quality. The data indicated the shift of energy to the upper

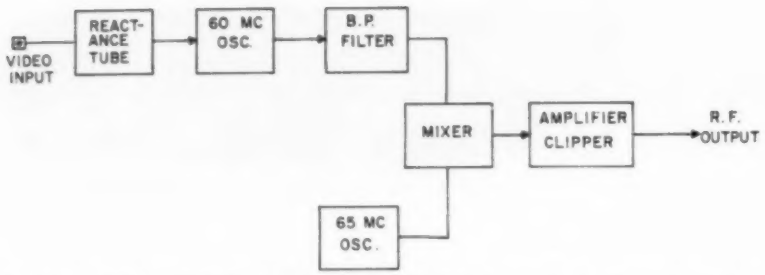

Fig. 1. Block diagram of modulator constructed to test theoretical assumptions concerning sideband and carrier energy in a frequency-modulation system in which modulating frequency approaches carrier frequency, and in which deviation frequency is small in relation to modulating frequency.

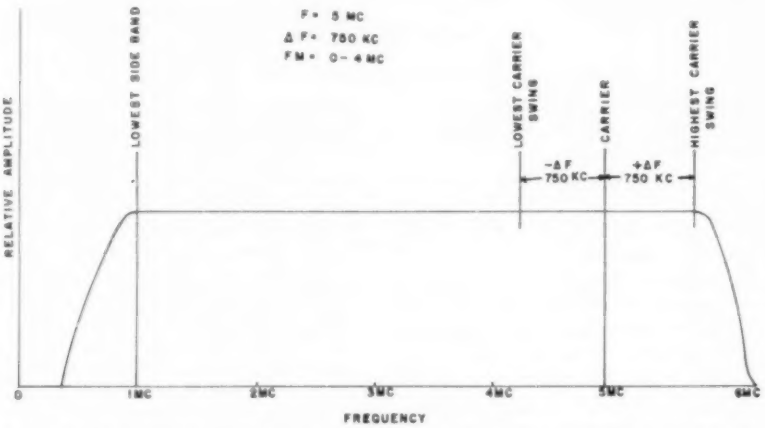

Fig. 2. Bandpass requirements for a frequency-modulation system like that used in the Ampex Videotape Recorder.

sidebands to be generally less than predicted by Cambi. We did not, however, have the time to explore this further.

The third question (c) of single or vestigial sideband transmission has been answered adequately, and it has been found to be no more of a problem with FM than with AM.

My associate, Harold Walsh, shows mathematically what happens when upper sidebands of a frequency-modulated signal are attenuated.

If a sinusoidal carrier sin $\omega_0 t$ is frequency modulated by the single-tone $A \cos \omega_1 t$, where A and ω_1 are such that, for the system, the deviation-ratio β is about 0.4 or less, then the modulated wave is:

$$i = J_0(\beta) \sin \omega_0 t + J_1(\beta) \sin (\omega_0 + \omega_1)t - J_1(\beta) \sin (\omega_0 - \omega_1)t \quad (1)$$

If the upper component, $J_1(\beta) \sin (\omega_0 + \omega_1)t$, is lost on the way between modulator and receiver limiter, so that the wave entering the latter is:

$$i' = J_0(\beta) \sin \omega_0 t - J_1(\beta) \sin (\omega_0 - \omega_1)t \quad (2)$$

this represents a wave simultaneously amplitude modulated and frequency modulated. This can be shown by adding to Eq. (2):

$$0 = \frac{J_1(\beta)}{2} \sin (\omega_0 + \omega_1)t - \frac{J_1(\beta)}{2} \sin (\omega_0 + \omega_1)t \quad (3)$$

The result yields:

$$i' = \frac{J_0(\beta)}{2} \sin \omega_0 t + \frac{J_1(\beta)}{2} \sin (\omega_0 + \omega_1)t - \frac{J_1(\beta)}{2} \sin (\omega_0 - \omega_1)t \text{ FM}$$
$$+ \frac{J_0(\beta)}{2} \sin \omega_0 t - \frac{J_1(\beta)}{2} \sin (\omega_0 + \omega_1)t - \frac{J_1(\beta)}{2} \sin (\omega_0 - \omega_1)t \text{ AM} \quad (4)$$

Now if the limiter wipes out the AM, the output is:

$$i'' = \frac{J_0(\beta)}{2} \sin \omega_0 t + \frac{J_1(\beta)}{2} \sin (\omega_0 + \omega_1)t - \frac{J_1(\beta)}{2} \sin (\omega_0 - \omega_1)t \quad (5)$$

and this is the original FM wave, complete with both side frequencies, but down 6 db.

If the reader wishes to extend the simple mathematics shown above, it will be noticed that the reconstruction process produces an upper sideband set whose polarity is opposite to that of the corresponding lower set. This is precisely what is required to match an odd-ordered lower band and precisely what is not required to match an even-ordered lower band. This complication might, in practice, lead to disastrous results if the reconstruction process were not confined to the range below approximately $\omega_0 - 2\Delta\omega$, where $\Delta\omega$ is the maximum deviation of the carrier. A table of significant sideband frequencies versus deviation-ratios shows this range to be practically free of significant even-ordered components.

To prevent the reconstructive process from operating in the range above $\omega_0 - 2\Delta\omega$, which is heavily infested with even-ordered components, all original upper band signal components in the range ω_0 to $\omega_0 + 2\Delta\omega$ must be trans-

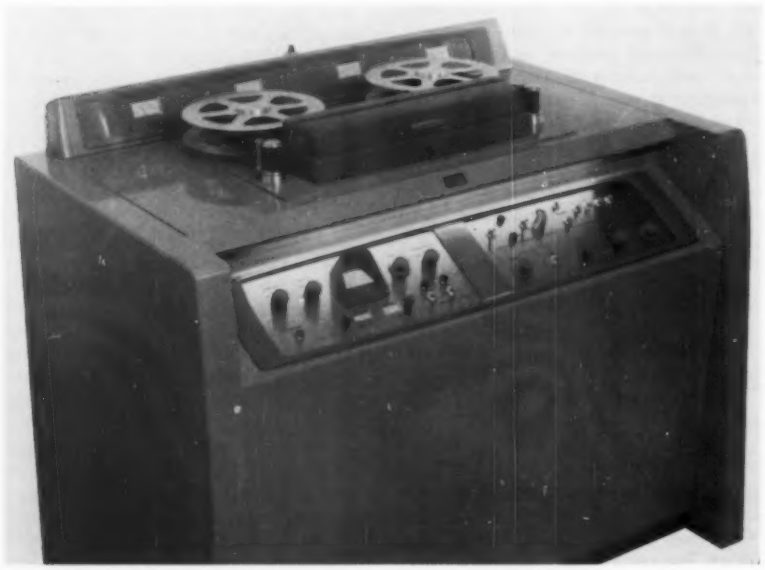

Fig. 3. The production model Ampex Videotape Recorder.

mitted without too much attenuation.

In practice, these limits may be diminished significantly before distortion becomes noticeable. Experience shows that only the upper components in the range $\omega_0 + \Delta\omega$ need be transmitted, and that if this minimum is met, picture quality is acceptable and distortion is either slight or not noticeable. Figure 2 indicates a system bandpass needed to handle a carrier modulated under typical conditions found in Ampex recorders in use today. Using practical values of F (carrier) = 5 mc, ΔF (deviation) = 750 kc, and FM (modulating frequency) ranging from zero to 4 mc, this necessitates a minimum pass band from 1 mc to 5.75 mc.

A Practical System

Production machines resemble earlier models. Externally, the newer equipment is pleasing to the eye, as Fig. 3 testifies. The equipment is also more pleasing to the operator, for pains have been taken to simplify controls and provide a flexible machine. A block diagram (Fig. 4) of the signal-handling portion of the recorder shows where some of this equipment ties in functionally. A signal of standard level and polarity is fed to the recorder, where it is amplified by conventional means (1) and applied to the grids of a multivibrator (3) via a cathode follower (2).

The output of an unbalanced modulator contains components corresponding to the modulating wave. In the case where modulation frequencies approach the carrier, the sidebands and modulating frequencies are added if the latter are not suppressed. This is exactly what happens in a multivibrator type of oscillator-modulator if care is not exercised to remove the modulating frequency components. The form of balancing now used is shown in Fig. 5.

On a black-and-white picture, video feed-through manifests itself as an effect which looks like fine hair waving to the right of sharp transitions. The corresponding effect in facsimile transmission has been called "Kendall effect."[3] On a color picture, where a great deal of energy is present at 3.58 mc, such feed-through is more obvious in the form of beat patterns on the screen as the 3.58 mc beat against the FM carrier.

If video feed-through is present at the output of a modulation process, trouble can be compounded by nonlinearities in the rest of the system. Beat notes become very obnoxious in color while the hair effect on both monochrome and color is objectionable. The head driving amplifiers are a particular nuisance. Each of the four video heads has an inductance of approximately 30 μh. Ignoring resonance, which occurs at slightly above 6 mc, the impedance to which the amplifier must supply constant current ranges from 140 ohms

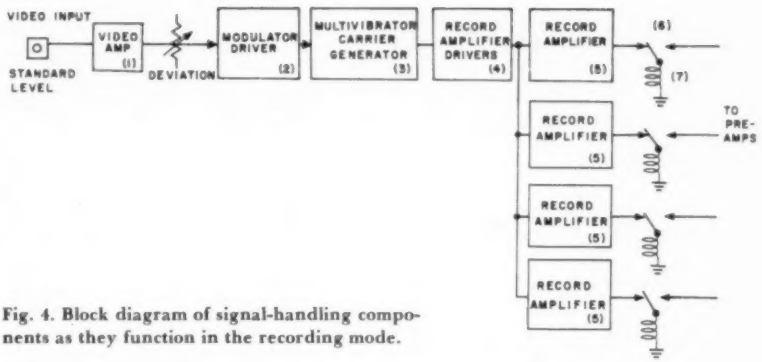

Fig. 4. Block diagram of signal-handling components as they function in the recording mode.

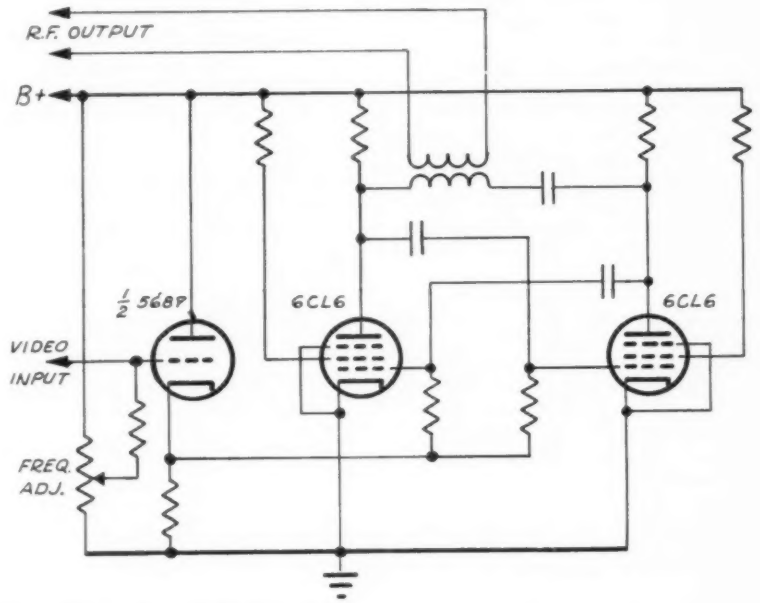

Fig. 5. Simplified schematic diagram of the modulator.

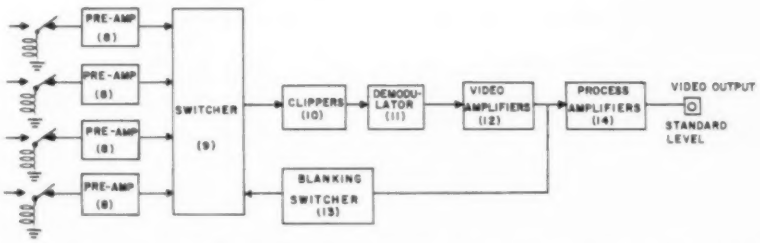

Fig. 6. Block diagram of signal-handling components as they function in the replay mode.

at 750 kc to 1130 ohms at 6 mc. An amplifier utilizing an EL-34 tube, with a 1-mh choke as a plate load, has been found to supply essentially constant current at an adequate level.

Signal Translation During Replay

For playback, the video heads are switched to an array of preamplifiers (see Fig. 6) to build the 2- or 3-mv signal to a suitable level where it can be sent to the switcher. A cascode input stage in the preamplifiers helps control the input noise to a reasonable level.[4,5]

The four-channel switcher has been described by Dolby.[6] Connection is made in turn to each of the four heads as it comes in contact with the tape. Since there is an overlap period of at least one picture line when two heads are reading the tape, switching is made to occur during the synchronizing interval.

The mixed output of the switcher

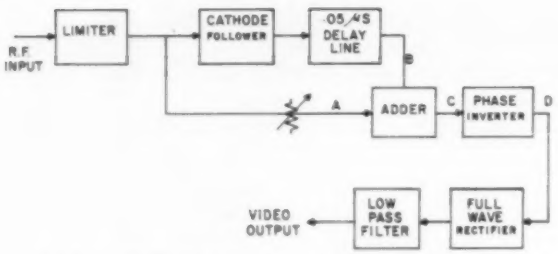

Fig. 7. Block diagram of the delay-line FM demodulator.

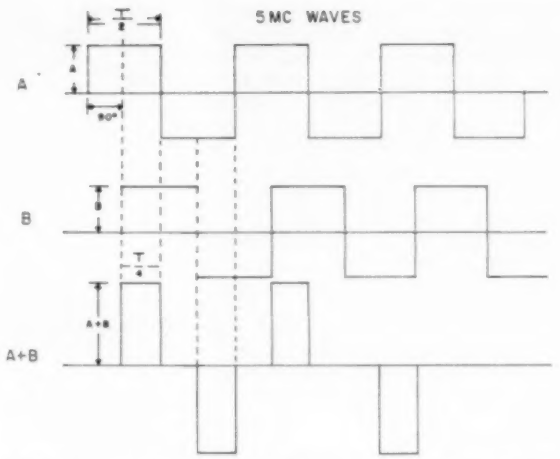

Fig. 8. Phase relations developed in delay-line FM demodulator, between direct and delayed 5-mc waves.

feeds cascaded limiters having 60 db of limiting action. This limiter strip in turn drives a delay-line type of demodulator. A block diagram of the circuit is shown in Fig. 7.

The delay is first chosen to represent a 90° phase shift at the carrier frequency of 5 mc, or 0.05 μsec. Figure 8 shows the phase relationships at the points marked A and B in the block diagram which are the inputs to the adder. The output of the adder is the series of positive and negative pulses of height A plus B and width $T/4$ giving an area of $(A + B)T/4$.

Suppose that the frequency be reduced to 4 mc. The relationships that now exist are shown in Fig. 9. The area of coincidence of the two waves is greater, and equals 0.375 T instead of 0.25 T, as before. If the area enclosed by the pulses is integrated by charging a capacitor, the capacitor will rise to a higher average d-c value as the frequency decreases.

In practice we will be dealing with sine waves.

Let a wave be represented by:

$$e = A \sin \omega t$$

Let T = time delay in seconds. The delayed wave will be:

$$e' = A \sin (\omega t - \omega T)$$

Adding the delayed and undelayed signals, we have:

$$\begin{aligned} e + e' &= A[\sin \omega t + \sin (\omega t - \omega T)] \\ &= A[\sin \omega t - \sin \omega t \cos \omega T - \\ &\qquad \cos \omega t \sin \omega T] \end{aligned}$$

This is a wave having the envelope amplitude E and phase shift φ, i.e.

$$e + e' = E \sin (\omega t + \varphi)$$

and

$$E = A\sqrt{(1 + \cos \omega T)^2 + \sin^2 \omega T}$$

$$\tan \varphi = \frac{1 + \cos \omega T}{\sin \omega T}$$

From this equation it can be seen that the resultant amplitude will vary as a function of frequency.

The transfer characteristic of the delay line translator is not linear; however, if the operating point of the slope is chosen correctly, there will be an appreciable portion of the curve that will give a straight line for all practical purposes. A plot of the output is shown in Fig. 10. Two values of T have been chosen here to illustrate the effect of changing the delay time. It can be seen that by adjusting the amount of delay the linearity and sensitivity of the circuit can be varied at will.

It is now obvious that here is our simple frequency-sensitive device to translate FM to AM. Figure 11 is a schematic of the demodulator. A transformer-type phase splitter is shown here, but a vacuum tube may be used instead if desired.

Figure 12 illustrates the advantages of the new type demodulator over the earlier one. Three curves are plotted together for comparison between the slope detector and the new type using both a transformer inverter and a vacuum tube. The lower end response in the transformer case was seriously impaired by the design of the transformer, but a little care can extend the useful range to a much lower value.

It can be seen that there is still appreciable distortion, but the distortion curve can be more easily matched with corrective networks than could the slope detector.

It might be interesting to note here that the very first FM pictures recovered from tape were not made with the straightforward equipment described here, but were made with a more complex and conventional system, using a heterodyned modulator described earlier. For playback, the recorded signal was heterodyned back to 60 mc with a suppressed carrier ring mixer,

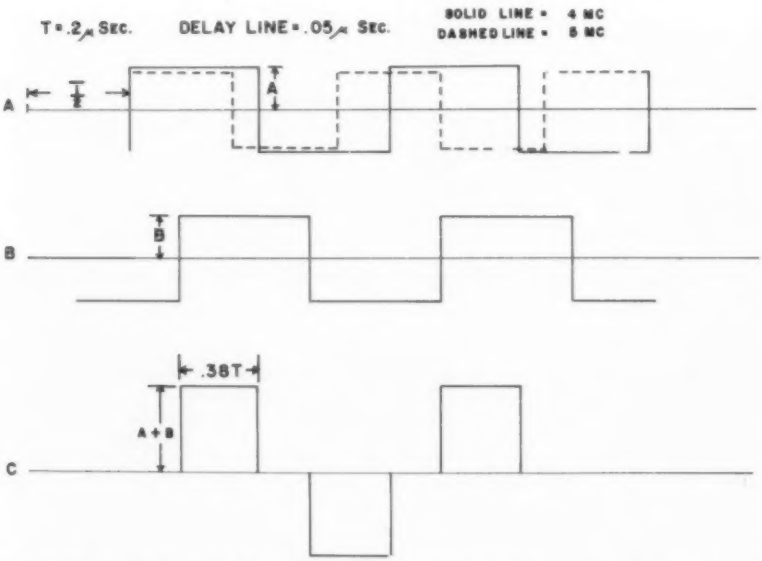

Fig. 9. Phase relations developed in delay-line FM demodulator, between direct and delayed 4-mc waves.

amplified with an IF strip, and demodulated by a discriminator. It worked, but was excessively complex. The heterodyne modulator may offer some advantages, in later work, with its ability to filter out unwanted modulation products, or "feed-through" of the modulating frequencies, but the heterodyne playback system seems far too complicated to warrant further investigation at this time. The present system does a satisfactory job.

The translation of the signal is almost complete at this point except for two additional refinements. If the switching process, described earlier, were allowed to take place more or less at random during the brief period of overlap when two heads are supplying signal, the switching process might produce a blip in the middle of the screen. To avoid this, some of the detected output is fed to a blanking switcher (13 in Fig. 6) which in turn directs the main switcher to change during blanking pulses only.

The second feature is the unique processing amplifier, described by Dolby.[7]

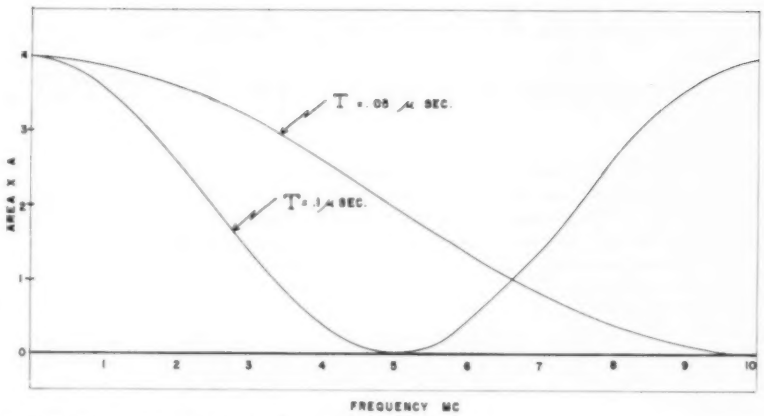

Fig. 10. Plot of output of delay-line demodulator.

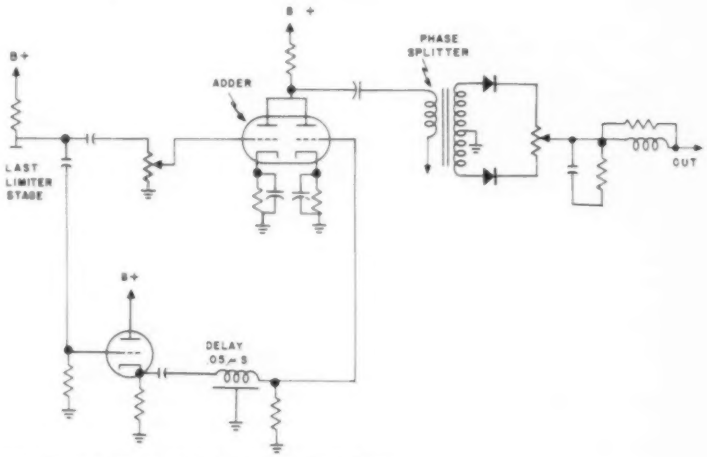

Fig. 11. Schematic of delay-line demodulator.

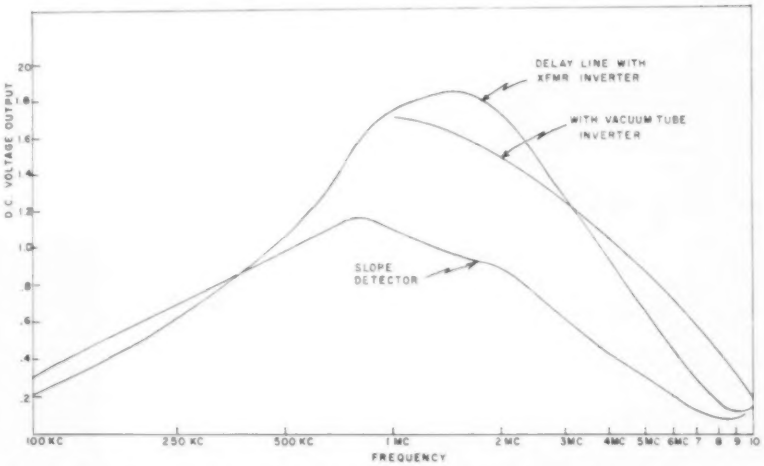

Fig. 12. Plot of comparative response of three types of FM demodulators.

Conclusion

At this writing, over one hundred fifty Videotape Recorders are in operation all over the world. All such recorders use the methods outlined here. It is felt that the use of frequency modulation as described is an adequate answer to the problems of video recording, and that any improvements in the immediate future will be refinements upon the basic system.

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The Video Processing Amplifier in the Ampex Videotape Recorder

By RAY M. DOLBY

Due to stringent requirements of network television, especially with regard to the shape and transient noise content of synchronizing pulses, a special "processing amplifier" has been developed to insure acceptable video waveform at the output of the Videotape Recorder. Similar in concept to a stabilizing amplifier, the new device represents a logical extension of stabilizing techniques. In addition to the usual stabilizing amplifier functions, the processing amplifier provides for complete reblanking of the video waveform and precise gating of the sync pulses, insuring that noise transients in the black direction will not project beyond reference black level during the active portion of the horizontal cycle. These operations are controlled solely by timing information in the incoming sync pulses.

THE PROCESSING AMPLIFIER in the Ampex Videotape Recorder is not an intrinsic part of the video-tape process. The Videotape Recorder will produce high-quality pictures without the processing amplifier, provided, however, that the images are viewed only on local monitors and that the output is not fed directly to network facilities. Designed to bridge this gap between the raw Videotape Recorder (VTR) output and a completely acceptable waveform for network handling, the intermediate processing amplifier is a necessary key to the practical commercial use of video tape.

Briefly, the basic purposes of the new unit (Fig. 1) are: first, to eliminate all objectionable noise in between or on the sync pulses; and second, to reblank the video signal.

Since playback video is not locked directly to local sync generators, timing information needed for the gating and blanking operations must be derived from the video signal itself.

Stripped from the playback video, VTR sync controls the vertical and horizontal gating generators, whose outputs are combined to energize a sync gate designed to pass incoming pulses only during those periods in which pulses should be present. Thus, transient noises between horizontal synchronizing pulses are completely blocked. The gating signal is also fed to the blanking former, which appropriately modifies the gating pulses and drives the reblanker. These operations of reblanking and of sync gating are the main ones responsible for insuring a VTR signal of good waveshape.

Trouble With Stabilizing Amplifiers

The basic difficulty with raw videotape output is that unavoidable transient noise arising from dropouts as well as head switching is found to be extremely obnoxious to stabilizing amplifiers and sync-tip clampers. Since, by design, a stabilizing amplifier clamps the picture to blanking level immediately after the trailing edge of any pulse which enters the sync region, a picture from a video-tape machine has a very unlucky time. Specifically, several lines of the picture are shaded abnormally by every noise transient. In some cases, depending on circuitry, the sync separators in the stabilizing amplifier will be upset, and patches of sync pulses may be missing from the resultant composite video.

An experiment at CBS in Hollywood illustrates these phenomena: A test pattern was recorded on good tape, played back normally, sent through the processing amplifier, and then fed to the studio facilities, including one stabilizing amplifier. Everything was adjusted properly, and the result was a high-quality image suitable for broadcast. Then the processing amplifier was removed from the system. The finished product (Fig. 2) reveals the sentiments of most stabilizing amplifiers about raw video-tape signal.

Processing Amplifier Design Considerations

It would be most desirable to gate all-synchronizing pulses through the processing amplifier only during those times in which any particular pulse should exist. In practice, this operation is fairly easy for the horizontal pulses, but predicting the arrival of the next legitimate pulse can become hopelessly complex in the vertical blanking period.

Figure 3 shows what actually was done. The idealized gating operation for the horizontal synchronizing pulses is achieved through the use of narrow keying pulses. Then, there is provided in the vertical blanking interval a wholesale passage for everything, including

Presented on April 29, 1957, at the Society's Convention in Washington, D. C., by Ray M. Dolby (then at Ampex Corp., 934 Charter St., Redwood City, Calif.; now at the Cavendish Laboratory, University of Cambridge, Cambridge, England).
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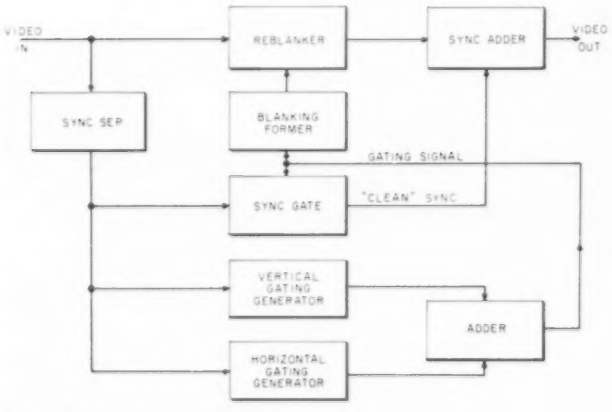

Fig. 1. Basic block diagram of the processing amplifier.

Fig. 2. Appearance of VTR picture after subjection to stabilizing amplifier—without processing amplifier.

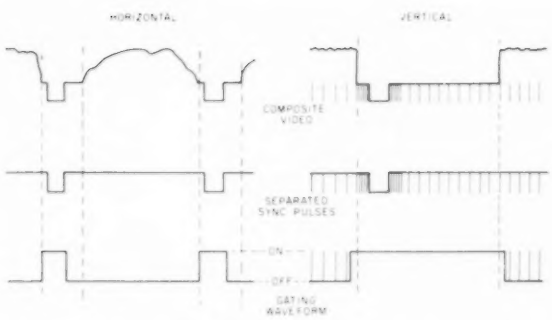

Fig. 3. Timing relationship between sync and gating pulses.

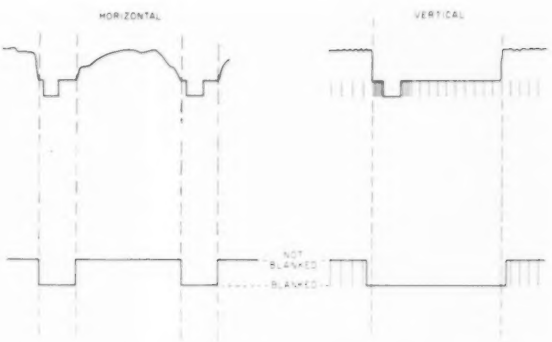

Fig. 4. Timing relationship between video and reblanking pulses.

noise. Justification for this procedure lies in the fortunate circumstance that during the vertical blanking interval noise pulses will cause stabilizing amplifiers to clamp, harmlessly, to blanking level only; therefore if noise is allowed to pass in this interval no difference will be seen in the picture.

In most stabilizing amplifier applications simple black clipping to remove the old synchronizing pulses and to clean up the front and back porches has proved to be satisfactory. But in the case of the Videotape Recorder there are, unfortunately, residual carrier components (remaining from the FM modulation-demodulation process) and other high-frequency noises on the sync pulses and blanking pedestals of the demodulated output. These high-frequency components give a fuzzy appearance to the back porch. Since any attempt to remove the fuzz with a black clipper will destroy setup to such an extent as to cut into the black portion of the video signal, the classical method clearly is not a satisfactory means for reforming the blanking pedestal.

The answer to this problem is to reblank the video signal, and the existence of the vertical and horizontal gating generators makes the formation of suitable blanking signals very easy. An examination of the required blanking signal and of the composite gating waveform shows that it is necessary only to delay the trailing edge of the gating signal a few microseconds in order to provide all of the necessary blanking information. Figure 4 illustrates the time relationship of the composite video and the reblanking pulses. The vertical reblanking pulse begins approximately half a line before the original blanking pulse began, and the end of the new blanking pulse occurs just after the end of the original blanking pedestal. In the horizontal period, the reblanking pulses are seen to coincide exactly with the timing of the original blanking pedestal.

Circuitry

Figure 5 is a basic outline of the circuitry required to perform the operations seen in the previous illustrations.

From the output of the machine, a 1-v video signal is fed to the input of the processing amplifier, after which it is amplified and given a preliminary clipping operation which removes black-going spikes projecting below the

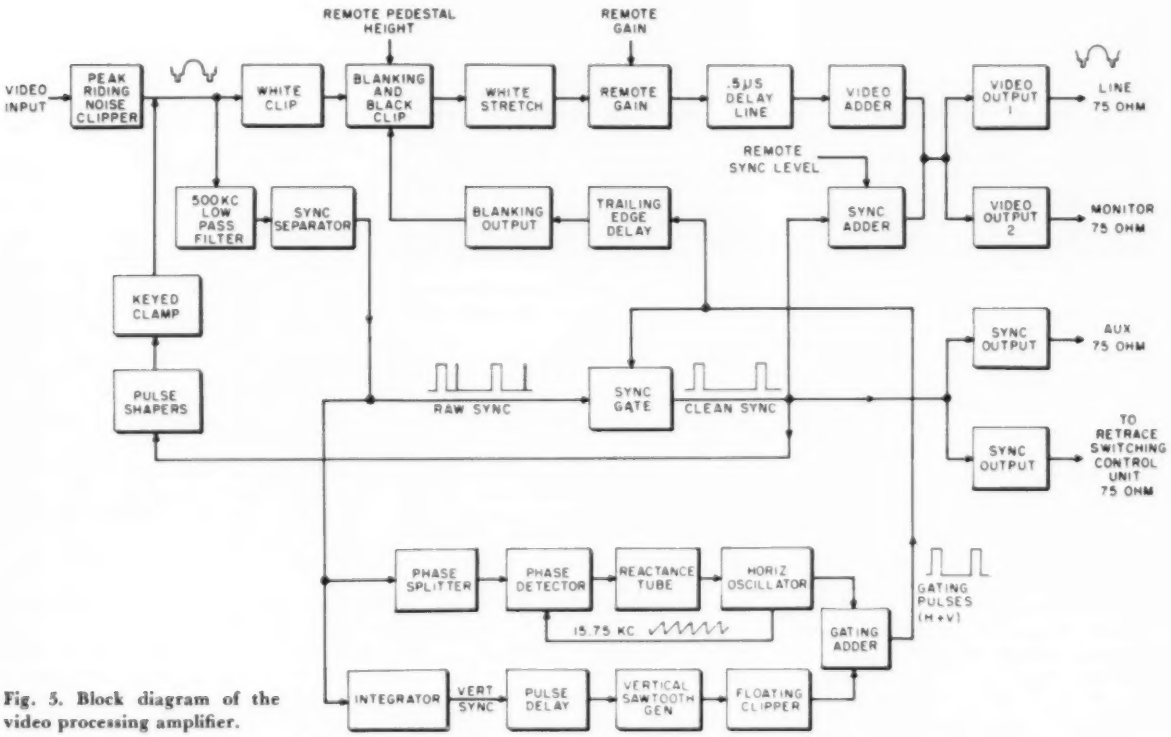

Fig. 5. Block diagram of the video processing amplifier.

Fig. 6. Oscillogram of processing amplifier input and output with noisy signal — expanded portion of vertical period.

Fig. 7. Horizontal waveforms. Conditions same as Fig. 6.

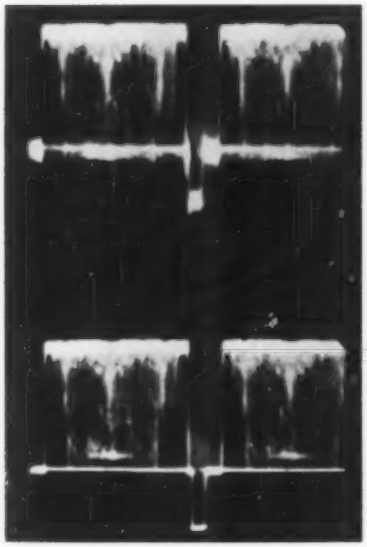

Fig. 8. Output of the VTR demodulator and subsequent output of the processing amplifier.

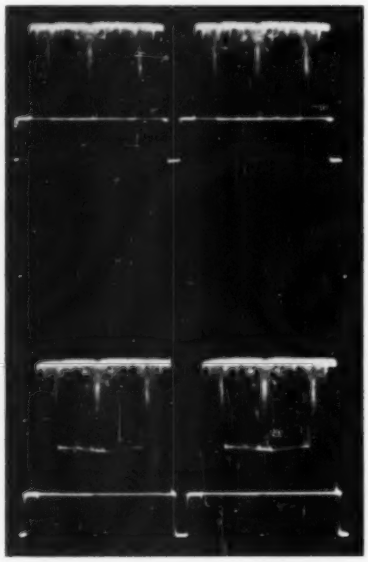

Fig. 9. Performance of processing amplifier in restoring setup to video signal with insufficient setup.

negative tips of sync. Clamped by a comparatively soft clamp only to restore the d-c component, the composite video is subjected to the white clipper and to the blanker and black clipper. The video signal, then without sync, is next applied to a direct-coupled white stretcher, a 6BJ6 variable mu tube. Similarly, the remote gain tube is a 6BJ6 with variable bias on the control grid. The use of variable bias permits remote operation through an accessory unit and switching relay which transfers control away from the main chassis.

Next, a $\frac{1}{2}$ μsec delay line appears in the chain of events, the purpose being to delay the video signal by the same amount as the synchronizing pulses have been delayed in their circuits, so that the timing relationship of the video signal and synchronizing pulses will be proper. After this point, the gated sync pulses are added and controlled either remotely or locally. Output from the machine is obtained through two identical feedback amplifiers with independent gain and output impedance controls.

Synchronizing pulses are obtained from a point near the clamp, after which they are sent through a 500-kc low-pass filter which removes carrier components in the signal as well as very short transient noises. The pulses then go to the sync separator, consisting of several triode amplifiers, all of which have been designed to provide very dependable operation under noisy sync conditions.

The raw synchronizing pulses, including noise, are then exposed to the selective action of the 6BN6 sync gate. The clean synchronizing pulses, which are the original pulses amplified and clipped in several stages, are then fed to the sync adder and to the two sync outputs. The clean pulses also energize the keyed clamper.

The horizontal gating generator is a sync controlled AFC circuit which generates pulses just slightly wider than the sync pulses themselves.

Also utilizing the raw synchronizing pulses, the vertical gating generator separates vertical information from the remainder with an integrator. The pulse delay delays timing information in the vertical synchronizing pulse for about 680 μsec, forming the end of the vertical gating pulse. But the leading edge of the vertical gating pulse is derived in a special sawtooth generator which delays time information in the previous vertical synchronizing pulse for almost one field. The horizontal and vertical gating pulses are combined in the gating adder and are fed to the suppressor grid of the 6BN6 sync gate. In addition, these gating pulses are sent to the reblanking former, which delays the trailing edges a few microseconds, forming the composite blanking signal, as described earlier. Blanking itself is accomplished by a diode clamp circuit.

Performance

To test the efficacy of the processing amplifier in treatment of signals much more noisy than it would be required to handle from the Videotape Recorder, an extremely bad air signal was taken from a tuner and fed to the input. Figures 6 and 7 show "before and after" examples. Figure 6 is an oscillogram of vertical waveforms corresponding to the input and output of the processing amplifier. The input signal is seen to contain practically all the noise ills that could possibly exist, the output corresponding to what would be expected from previous discussions. The view shown in Fig. 6 is a magnified portion of the vertical period.

Figure 7 shows the horizontal waveforms under the same conditions. Here again, the gating of the synchronizing pulses and the reblanking operation reconstruct the video signal into an acceptable form. The processing amplifier can be easily set up to match the output signal to either standard levels of pedestal and

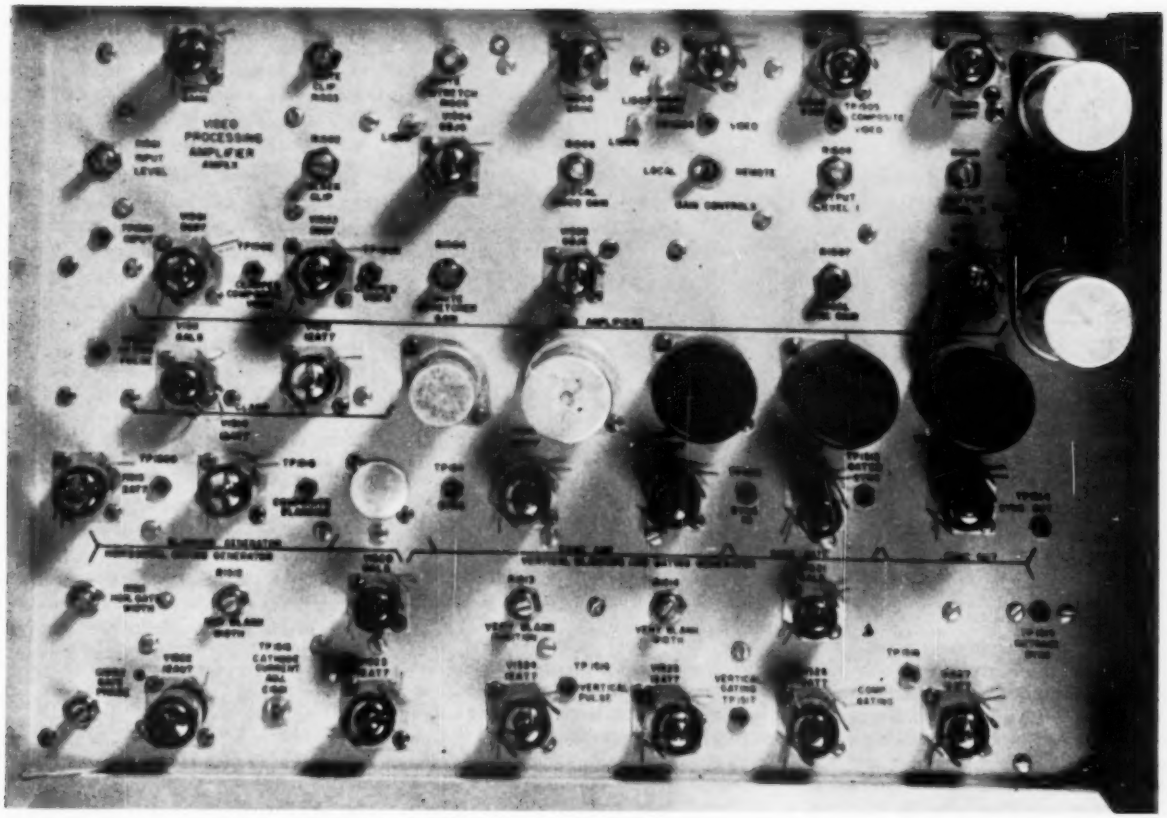

Fig. 10. The video processing amplifier.

sync or to the levels existing in the input signal.

Figures 6 and 7 are intended only to demonstrate the maximum capabilities of the processing amplifier; Fig. 8 is an indication of actual performance with video-tape signal as input. While they are fewer than in the previous illustrations, faults in the VTR waveform are easily noticed. There is the characteristic carrier "grass" (noise) on the front porch, synchronizing pulse, and back porch, and, although they may not be seen in this picture, noise transients do exist. The output synchronizing pulses are clean and well defined, yielding a signal completely compatible with network practices.

In practical use of the new unit as a stabilizing amplifier, another virtue in addition to signal clean-up is realized. Figure 9 is an illustration of the ability of the device to restore setup to a video signal with insufficient setup. A composite video signal will, after repeated subjection to stabilizing amplifiers, lose the normal setup. Furthermore, the usual stabilizing amplifier loses its ability to clean up the back porch after setup has been destroyed, for if the black clipper cuts deeper into the blanking pulse, the black tips of the video signal also will be distorted. Provided with a local and remote pedestal height control, on the other hand, the processing amplifier will recreate any desired amount of setup. The bottom half of the figure gives an idea of what is possible.

The New Unit in Use

The processing amplifier (Fig. 10) has been in commercial use in the Ampex Videotape Recorders since November 1956, when Television City (CBS), Hollywood, began the first regular programming with magnetic tape.

While the unit was designed specifically for the Ampex Videotape Recorder, its adaptability to other uses has become obvious. Suitable applications for the processing amplifier can be inferred from its performance in relation to the video-tape signal. As a stabilizing amplifier, the unit probably would find its greatest value on the receiving end of a network broadcast for re-formation of blanking pedestals and general cleaning up of the synchronizing pulses. In addition to usual studio applications for conventional stabilizing amplifiers, the new unit might also have value as a device to restore noisy air signals for isolated communities which rely only on air relay of television for local redistribution.

It is expected that, eventually, as video-tape production demands become less pressing, attention can be turned to making the processing amplifier available as an entity.

It seems reasonable enough to restore a noisy signal by reblanking and sync gating through the use of appropriate pulses derived from the signal itself, but it had never before been necessary to produce such a device. The advent of the Videotape Recorder precipitated the design of the necessary circuits; the processing amplifier emerged as the consequence of the given requirements.

Techniques in Editing and Splicing Video-Tape Recordings

Editorial Note: Shortly after the Ampex VR-1000 Videotape Recorder was made commercially available, it became apparent that, because of special problems, development of a satisfactory method for editing and splicing video tape was of immediate importance. The two following papers (each slightly condensed) describe the steps leading to the development of the Ampex splicing method. The first paper, presented at the 1957 Spring Convention in Washington, D.C., outlines early experiments and problems encountered. The second paper discusses in detail the method finally adopted.

Factors Affecting the Splicing of Video Tape

By KURT R. MACHEIN

Video tape can be spliced, but techniques applicable to photographic film or recorded audio tape are not suitable for video tape. Splicing and editing of video tape are possible and practical but are a special process quite unlike the splicing of photographic film or audio tape.

AUDIO-TAPE RECORDING consists of one longitudinal recording and the only conditions which must be observed in splicing are tape speed and head alignment, but the factors involved in splicing video tape are much more complex and the requirements much more stringent. Video-tape recording consists of three different recordings: (1) transverse picture information; (2) longitudinal audio recording; (3) longitudinal control track. The spatial relationship existing among the three recordings is of great importance and must remain constant within certain tolerances if the recorded program is to be properly reproduced.

In cutting and splicing video tape, certain conditions are necessary: (1) At the transition of the splice, the head which starts to play back the first track after the splice must find this track sufficiently well positioned in the lateral direction to allow the machine to recognize the vertical interval without confusion. (2) The spatial relationship between the control track on the first tape and that on the tape to which splicing is to be done must be such that the capstan servo amplifier is not subjected to sudden phase shifts which might throw the servo out of control. (3) The tracking error generated at the moment the splice passes the video head must be small enough so that the new tape tracks smoothly and excessive noise will not appear in the picture.

Figure 1 is an enlargement of the upper 0.7 in. of a video tape showing the composite signal. The unrecorded audio track, erased by the audio erase head, appears as a wide longitudinal stripe along the upper edge. Vertical synchronization pulses appear at intervals of 16 video tracks. In splicing, the cut must be made inside a 5-mil space next to a vertical synchronization pulse.

If, at the moment a splice passes the rotating head during reproduction, a tracking error of not more than 20% is to be permitted, the accuracy of splicing must be ± 2 mils, since one track is 10 mils wide. Tracking is accomplished, during reproduction, by observation of the phase of the 240-cycle control-track signal. Plus or minus 2 mils corresponds to a peak-to-peak error of 23° for the 240-cycle signal. In other words, each tape splice must display a phasing error not exceeding 11.5° on the control track.

An examination of the problem indicated that the most suitable point at which to cut the tape would be the transverse track which carries the vertical blanking interval. This occurs on the tape at $\frac{1}{4}$-in. intervals and is slightly longer than one scan of a transverse track. The recording is not normally visible on the tape so it was necessary to devise a method by which the required track can be identified.

One approach investigated for this purpose involved the electromagnetic detection of a prerecorded editing pulse by means of a reproducing head whose output was dependent only on amplitude of magnetic flux, and independent of the rate of change of flux. An editing pulse

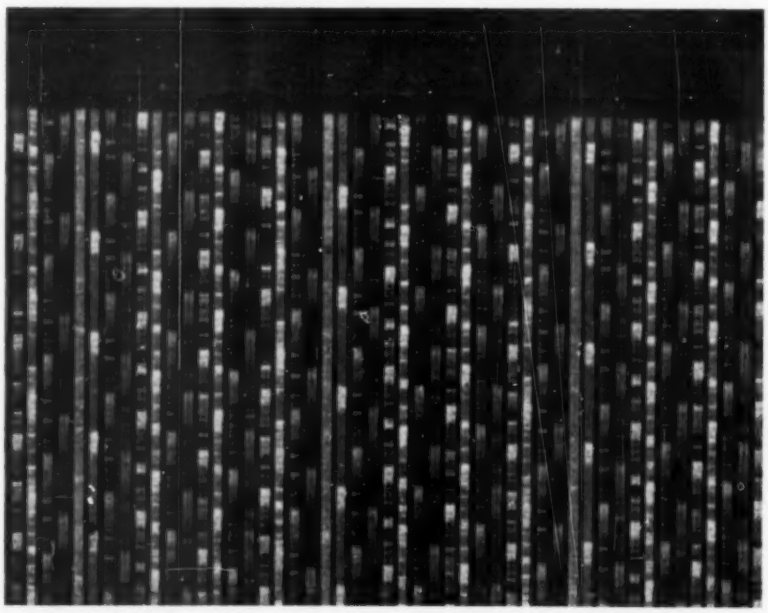

Fig. 1. Upper 0.7 in. of a "developed" video tape. The recording contains the entire composite video signal.

Presented on April 29, 1957, at the Society's Convention in Washington, D.C., by Kurt Machein, Ampex Corp., 934 Charter St., Redwood City, Calif.
(Revised paper received on September 29, 1958.)

derived from the incoming video signal and recorded on the control track, and thus bearing an exact and clearly defined relation to the picture information on the transverse video tracks, could then be detected, independently of tape motion, by the flux sensitive head mounted on an editing device. For very accurate indication of the edit pulse position, the rise time and duration of the pulse must be short, and it was in this connection that the flux-sensitive head approach lost its appeal. The magnetic field of the short pulses was not large in comparison with the earth's magnetic field, and consequently the use of flux-sensitive heads would have required a very careful adjusting process in order to achieve a null with respect to the noise source. Magnetic fields generated by the recorder would also have to be taken into consideration.

Other experiments were conducted to determine which of several methods would be the most satisfactory in developing the magnetic tracks into contrasting, easily visible images.

In working out the method which was later adopted, experiments were conducted using various liquids containing carbonyl iron in suspension. These were the requirements: (1) the liquids used must in no way affect the Mylar backing or the oxide binder on the tape; (2) the liquids must be of a volatile nature; and (3) after splicing, the image produced must be easy to remove, wet or dry, by a simple "wipe" process.

With this method, when the tape is immersed in the liquid, iron particles precipitate on the tape in a selective manner, the density of the deposit being approximately proportional to the magnetization of the tape at this point. After the tape dries, an optical image, which shows the signal path and the impressed variations on it, becomes visible.

Figure 2 is a photomicrograph of the lower 0.7 in. of a video tape showing carbonyl iron particles tracing magnetic patterns. This pattern displays only synchronization pulses in the absence of video information. The recorded 240-cycle control track is seen at the lower edge and horizontal synchronization pulses are seen as small square markings along the video tracks. Three vertical bars

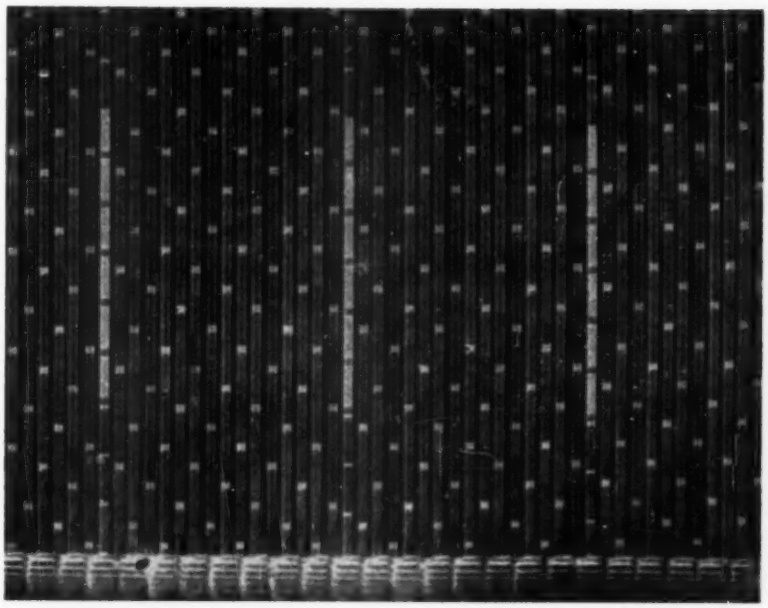

Fig. 2. Photomicrograph of a "developed" video tape. Carbonyl iron particles trace the magnetic pattern. The image was developed and completely dried in less than 3 sec.

define two complete fields, or one complete frame of picture.

With an optical device of approximately 10 powers, the vertical blanking interval can be distinguished from the horizontal pulses and the rest of the video information. The vertical blanking interval appears on the tape as a solid track, starting in the lower third of a single transverse track and lasting for approximately the length of one track. Since the position-servo of the recorder keeps the beginning of the blanking period within very close tolerances to plus-or-minus one horizontal line, a cut between the two tracks carrying the vertical interval can be made if accuracy of ± 1 mil is maintained. The second tape, which is spliced to the first, is cut in a similar manner.

Further experiments have demonstrated the soundness of this approach. In the laboratory, a number of splices were produced in this manner, using conventional thin, high-strength splicing tape. The splices passed the video head without disturbing the picture on the screen. The slight increase of the thickness and stiffness acts as a small additional load on the head drum, momentarily slowing down the speed. This speed variation is quickly corrected by the servo amplifier after the splice has passed. There is a slight tendency for the picture to rock a little horizontally for a half second or less.

Other splicing methods under consideration at various times included the use of a ferric compound solution which would be swabbed on the tape and a reagent added which would allow a selective plating process to occur. The precipitated ferric particles thus released would trace out the magnetic impressions. Another method involved the use of a dye with a high ionic affinity which would leave a deposit in proportion to the tape signal amplitude.

The goal during all this experimentation was to achieve a simple, accurate, practical splicing method which would meet industry requirements arising with the expanding use of video-tape recording.

Electronic Marking and Control for Rapid Location of Vertical Blanking Area for Editing Video-Tape Recordings

By JOSEPH ROIZEN

A relatively simple and inexpensive method for splicing video tape has been developed. Three problems were investigated: (1) visual "development" of the video track; (2) accurate positioning of the splice; (3) joining tapes to achieve maximum mechanical strength. Electronics have been included in production machines to provide accurately spaced "edit" pulses to position the splice. Simplified tray spray "development" methods have been attained.

A PRELIMINARY STEP toward developing a method for accurately editing and splicing video tape was that of interviewing network engineers on their day-to-day problems. Data gathered in this manner provided a basis for experimental and testing work. Three basic problems were dealt with in early research and experiments: (1) the visual "development" of the magnetic image on the tape; (2) the accurate positioning of the splice in relation to the small mechanical tolerances within which the transition must be placed; (3) the method of joining tape ends to achieve maximum mechanical strength and minimum effect on the head drum assembly. Following extensive study and testing, a basic method of utilizing magnetically influenced particles in a high vapor pressure liquid suspension was adopted.

Tests were conducted to determine optimum particle size (ranging from 1 to 20 μ) which would give sharply defined read-outs on short duration, fast-rise time pulses. Particles in the 3- to 5-μ range proved ideal for this application. All magnetic metals obtainable in fine powders including iron, nickel, cobalt and stainless steel were checked for availability, ease of handling and reflectivity. Both carbonyl iron and stainless steel proved to be usable, each having specific advantages depending on the application.

The selection of a liquid carrier for the particles was limited to materials meeting these specifications: (1) low toxicity; (2) high vapor pressure for rapid read-out; (3) safety for use with the Mylar backing; (4) ease of cleaning so as to leave no residue on the tape and; (5) low viscosity to permit good mobility of the particles as they settle.

Several liquids proved to be acceptable. The two most common and easily available are lacquer diluent which is an industrial cleaning fluid; and Freon TF, a film cleaner. A commercially available package, called Ampex Edivue, consists of a suspension of carbonyl iron and diluent in a wide-mouth jar that can be used to "visualize" the video tape without needing a separate tray. As the diluent evaporates with the resulting increase in suspension density, a replenishing supply of liquid should be provided to maintain the original concentration.

The problem of positioning the splices required careful examination. The logical location for a splice is during vertical blanking time and after vertical synchronization has occurred. Under these conditions the home viewer will not see the splice going by because both video and sync continuity will be maintained and the transition will occur at a time when the vertical oscillator has just been fired and cannot be triggered again. The video at this point is blanked or out of sight at the top of the picture. Figure 1 shows a visualized tape using a stainless-steel developer. A regular monoscope pattern is recorded on the tape. The pulses along the bottom edge of the tape are spaced under the vertical blanking area on a monoscope recording. A video signal that may contain low brightness levels with all the information near blanking level would make it impossible to differentiate the blanking area from the rest of the video scans. Experimental data also showed that to maintain stability during a splice, it was of the utmost importance that the 240-cycle control track phase shift at the splice be kept under 15°. These two conditions made explicit the need of electronically marking the tape in such a way that the exact splice point would invariably be readily visible.

The circuitry to generate a high-amplitude, short-duration pulse, which is referenced to the vertical sync of the incoming video signal and the 240-cycle control-track signal was then developed (Fig. 2). This pulse is superimposed during record mode on the control-track signal and appears as a sharp blip on the bottom edge of the video tape when it is "visualized." The servo control unit includes a coincidence gate which is open for approximately 300 μsec by vertical sync and allows the differentiated rise-time pulse (approximately 100 μsec) of the 240-cycle signal from the photocell on the head assembly to be superimposed on the control-track recording. This assures that edit pulses will only be laid down when the recorder is in stable operation and that, when recorded, they will be at some fixed phase of the control-track signal. The edit pulses can then be positioned accurately in the proper relationship to the video signal by manual adjustment of the control-track record head. Figure 3 shows the waveforms of this circuitry.

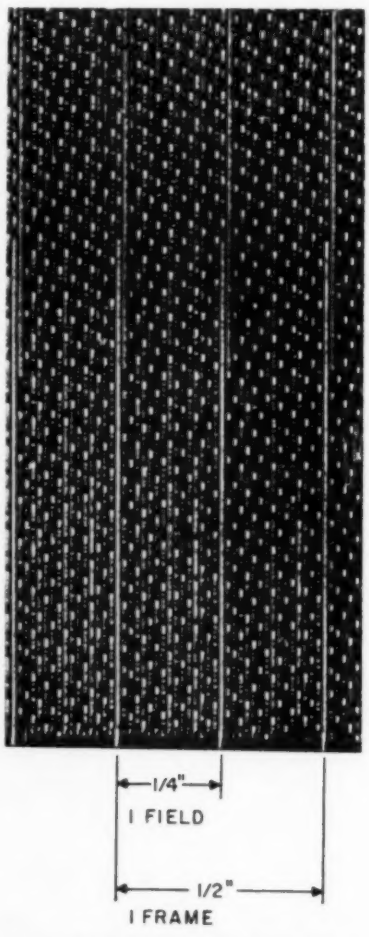

Fig. 1. Monoscope pattern recorded on tape. The vertical blanking intervals appear as long lines and horizontal sync pulses show as the pattern of dots between them.

Presented on April 24, 1958, at the Society's Convention in Los Angeles by Joseph Roizen, Ampex Corp., 934 Charter St., Redwood City, Calif.
(Revised paper received on September 29, 1958.)

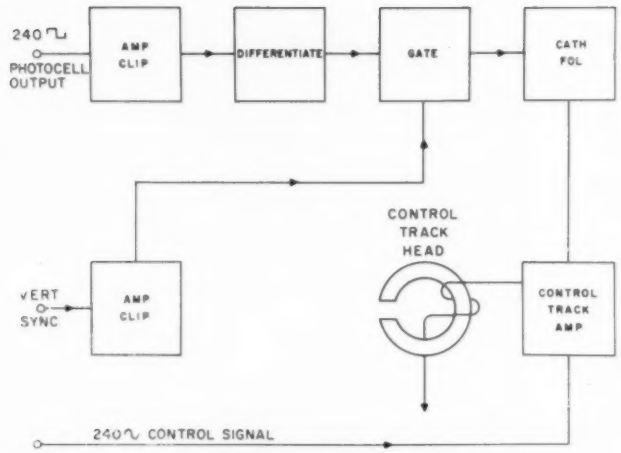

Fig. 2. Block diagram of system for edit pulses applied to the control track record head through the control track amplifier.

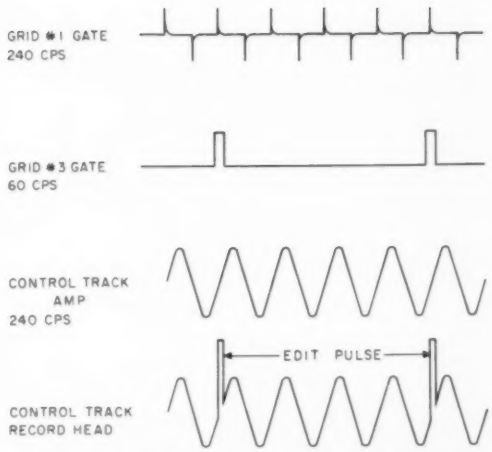

Fig. 3. The action of coincidence gate which allows the vertical sync at Grid 3 to gate through edit pulses phased to control track.

Joining the Tapes

The problem of how to join the tapes required careful consideration. There are four methods by which Mylar tapes can be spliced: (1) welding by controlled heat and pressure; (2) welding by dielectric heating; (3) overlapping an adhesive joint; (4) butt-jointing with pressure-sensitive backing tape.

The overlap adhesive joint and the heat and pressure methods were discarded, the first because of the limitation of a 5-mil overlap, and the second because the area around the splice becomes brittle and breaks at 10 to 15 lb.

A butt joint made with extra thin (under 1-mil) splicing tape, $\frac{1}{4}$-in. wide, was adopted as the best available method, and the project of developing a precision splicer was launched.

Before the precision splicer was complete a small manual splicing jig was made available. With this device, two tapes are held in good longitudinal alignment and a milled-out slot, angled correctly, against which a 6-in. straightedge is laid is the cutting guide for an Exacto knife or razor blade. The edit pulse is lined up against the straight edge and two similarly cut tapes can be butted together and spliced with thin backing tape.

The precision splicer (Fig. 4), developed later, simultaneously cuts two tapes that have been properly positioned in it with the edit pulses lined up under hair lines of the glass cutting guide. A three-position knob allows excess ends of video tape to be cleared away and the splicing tape to be pulled forward. The video tape then drops down on the adhesive side of the pressure-sensitive backing and a squeegee-type pressure pad is applied to seal on the backing. The excess backing tape is trimmed off and the splice is finished. Since edit pulses appear at every field, a defective splice can be corrected by cutting out two fields, which results in a loss of only $\frac{1}{30}$ sec of picture information.

Fig. 4. Splicing device in use.

Editing of the video-tape recording must be done on a video-tape recorder. As the tape is played back, either sound or picture can be used for selecting stop and start points. The precise braking characteristics of the video-tape recorder allow a predictable amount of tape to go by the head drum after the stop button is pressed. The mark on the back of the tape and a paper marker insert serve to locate the spot again. Cutting out or splicing in a section of tape can then be accomplished. Since the edit pulses appear at every field, 60 splicing points at $\frac{1}{4}$-in. intervals in every second of picture information are provided.

Since it is possible to erase and record audio without affecting the picture, sound dubbing is no more difficult than with standard audio recorders using present-day studio techniques.

The method of splicing video tapes, described above, seems entirely practical as a means of meeting immediate needs. Continuing research will undoubtedly lead to improvements and to new developments for recording and duplication of video tapes.

Magnetic Tape for Video Recording

By ROBERT A. von BEHREN

The new video-tape recording systems now in commercial and experimental use require special magnetic tapes differing in design from standard types, and manufactured to a standard of perfection which a short time ago it was believed impossible to achieve. This paper discusses some of the unique features of video-recording tapes and the problems encountered in their development.

THE ANNOUNCEMENT in March 1956 that the three major television networks had placed orders for Ampex video recorders precipitated a large and concentrated effort to perfect a magnetic tape for use on these machines. Actually, no completely new concepts were introduced into magnetic-tape technology by the Ampex machines. Except for a few obvious peculiarities due to the rotating-head scanning method, the requirements for tape were essentially the same as for other TV recorders. The real challenge arose out of the fact that these machines were moving rapidly out of the laboratory and into the commercial world where *quantities* of high-quality and reliable tape would be needed to sustain TV network operations. It is of interest here to examine some of the problems encountered in the development of video-recording tape for this critical application.

Special Requirements

One obvious requirement for a video recorder is the ability to record a wide spectrum extending from a few cycles per second to about 4 megacycles.[1] If one were to try to meet this requirement by merely increasing the speed of the tape past the head, a number of serious problems would be encountered. Many of these, such as the difficulty in recording low frequencies (as well as high) and the severe requirements of amplitude and phase equalization have been obviated in the Ampex recorder by the use of a FM carrier.

An additional innovation in the Ampex machine is the method of scanning the tape transversely with a set of rotating heads. This effectively chops the active video track in short segments and arranges them side by side instead of end to end on the tape, permitting some half million lineal feet of recorded track to be carried on a 5000-ft roll of tape.

Necessary Compromises

On the negative side of the ledger, these gains have not been achieved without making some compromises in other areas. In the Ampex machines, the track width has been reduced to only 0.010 in. and the minimum recorded wavelength to something like 0.2 mil. Both of these factors tend to reduce the signal-to-noise ratio of the system. It is interesting to note that the Ampex video recorder utilizes only about $\frac{1}{16}$ as much tape area per unit of bandwidth as conventional audio recorders. That is, the video recording channel occupies some 250 times the spectrum of audio channel, but the rate of tape consumption is only 16 times as great.

In addition, the FM carrier method introduces a further complication. Whereas in most recorders, the zero signal noise level is determined by the residual noise of erased (i.e. magnetically neutral) tape, in the Ampex machine the carrier signal is at all times impressed on the tape. The zero signal noise level is therefore comparable to the modulation noise of the tape, which may be 10 to 20 db higher than the erased noise level. It is well known that the usual noise-suppression mechanism associated with the FM carrier transmission does not pertain to the Ampex system because the carrier frequency is only slightly higher than highest video frequency.

The factors just mentioned all conspire to reduce the signal level and increase the system noise to the point where the signal-to-noise ratio of 35 db required for network video transmissions is difficult to obtain. The first problems to be solved, then, were to increase the output of video-recording tape at extremely short wavelengths and to reduce the modulation noise. Fortunately, these problems were related in that the methods used to gain increased output also helped the noise situation.

It became immediately apparent that orienting the particles of the magnetic coating with their easy axes in the direction of recording (i.e. transversely) would help this situation. Orientation is, of course, standard practice for tapes in which the recording is longitudinal, but the usual techniques for accomplishing this do not lend themselves to transverse orientation. This necessitated the development of some completely new manufacturing techniques and considerable revision of production equipment. Needless to say, transverse orientation was accomplished, and is now employed as a routine matter in the production of video recording tape. While this factor alone accounted for perhaps 3- to 5-db improvement in signal-to-noise ratio, further improvement was needed.

It is well known that the efficiency of a magnetic tape for recording and reproducing very short wavelengths is generally related to surface smoothness. However, the importance of this can best be appreciated by reference to some theoretical studies of the reproducing process.

Calculations by Wallace[2] and independently by Westmijke[3] show that for a tape which was originally magnetized uniformly throughout its thickness, and according to a sinusoidal pattern of wavelength (λ) in the recording direction, the effectiveness of the magnetized particles in producing flux in an ideal playback head is given by exp. $[-2\pi d/\lambda]$, where d is the distance of the particle from the reproducing-head surface. The physical significance of the relationship is that for very short recorded wavelengths the magnetic flux contributed by particles situated deep in the tape coating closes upon itself without linking the playback head. Therefore, the relationship provides a means for estimating the depth of the effective portion of the tape coating at short wavelengths.

Values of wavelength appropriate to the FM carrier frequencies of the Ampex system have been inserted in this formula, and the "penetration" curves of Fig. 1

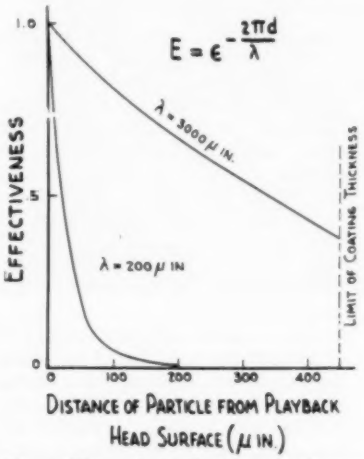

Fig. 1. Theoretical effectiveness of magnetized particles vs. distance from the playback head surface. For short recorded wavelengths only the surface layers of the tape coating contribute to the playback signal.

Presented on October 5, 1957, at the Society's Convention at Philadelphia, by Robert A. von Behren, Minnesota Mining and Manufacturing Co., Magnetic Products Div., 2301 Hudson Rd., St. Paul 6, Minn.

(This paper was received on August 8, 1958.)

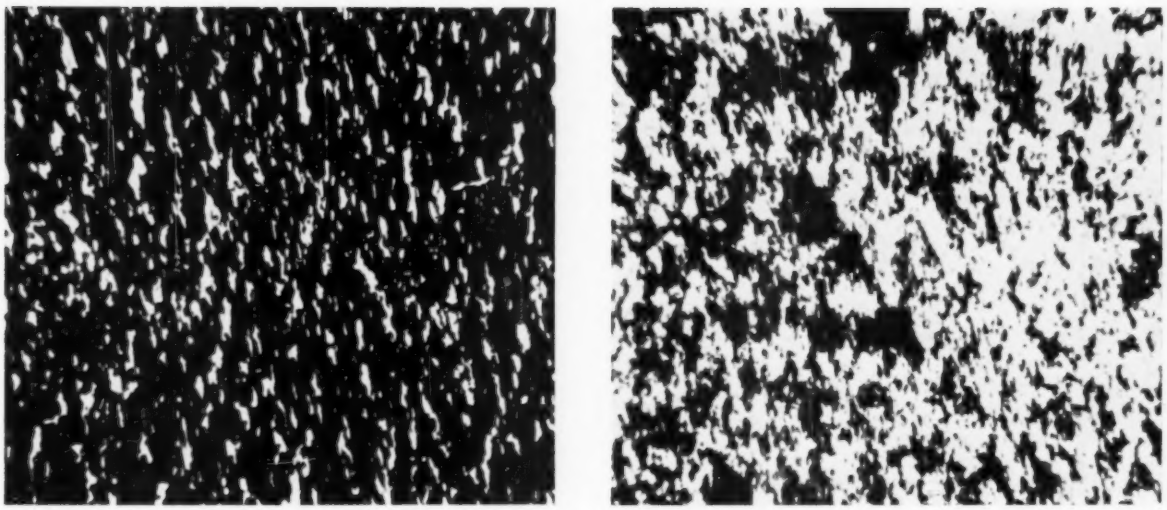

Fig. 2. Photomicrographs (50×) comparing surface characteristics of conventional tape (left) and video recording tape (right). Only the light areas are in close contact with the recording heads and hence effective for video recording.

result. At the lowest carrier frequency of 500 kc corresponding to a 3-mil wavelength, the effectiveness of the coating drops slowly, reaching only 40% at the back of the 450 μin. coating. This situation is not serious, as it is in the case of the lower curve representing the highest carrier frequency of 7.5 mc (0.2-mil wavelength). At this frequency, fully 50% of the signal intensity is contributed by the first 20 μin. of the coating, and almost all of the effective particles are confined within the first quarter of the tape thickness. This means that if there are relatively few magnetic particles within the effective region nearest the reproduce head, for instance, because of surface roughness or dust inclusions, the signal level will be weak. Moreover, if these conditions tend to vary from point to point as the head passes over the tape, the signal will be unsteady and the noise high.

It is easy to appreciate the seriousness of this problem when one realizes that the needle-shaped particles of magnetic oxide are themselves perhaps 10 μin. in diameter and 50 μin. long. Of course, this theoretical treatment is greatly oversimplified, and therefore inaccurate, but it does yield a useful insight into the importance of surface smoothness for video recording. In a general way, good correlation has been obtained between output and noise characteristics of tape samples, and surface smoothness as observed microscopically.

Improvement of Surface Characteristics

It is noted that considerable progress has been made in perfecting the surface characteristics of video recording tape coatings. Accomplishments in this direction are illustrated by the photomicrographs of Fig. 2. These photos were taken

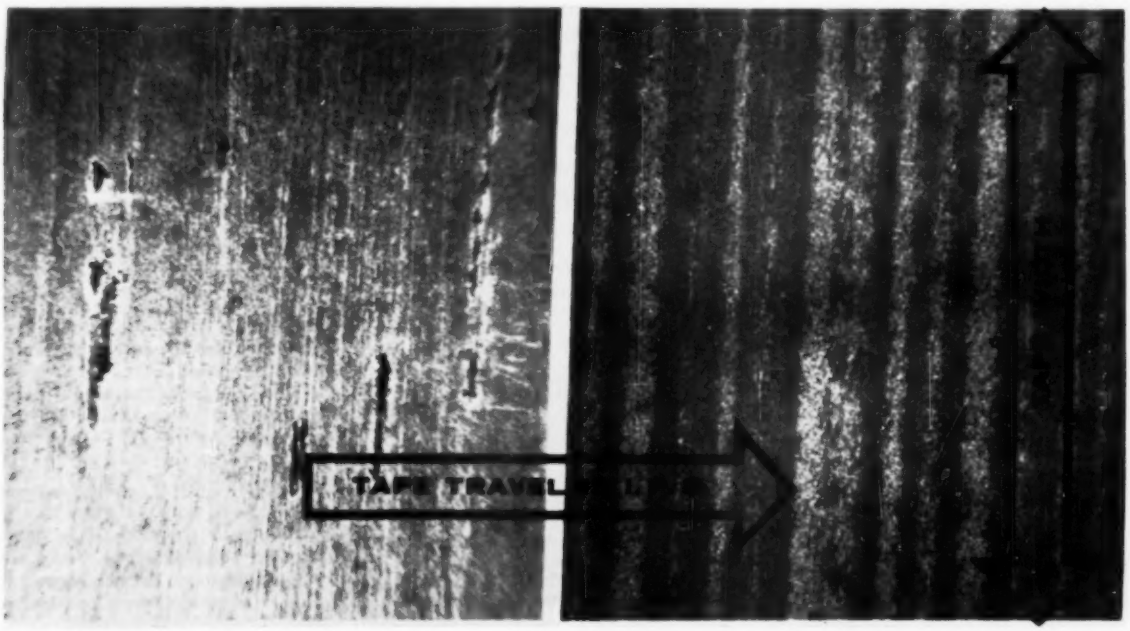

Fig. 3. Photomicrographs (35×) showing wear patterns of conventional, early experimental recording tape (left) and "Scotch" brand video recording tape No. 179 (right). Severe ruboff deposits were present in conventional tape after only 15 passes through the Ampex video recorder, whereas the "Scotch" brand video recording tape was perfectly clean after 320 passes.

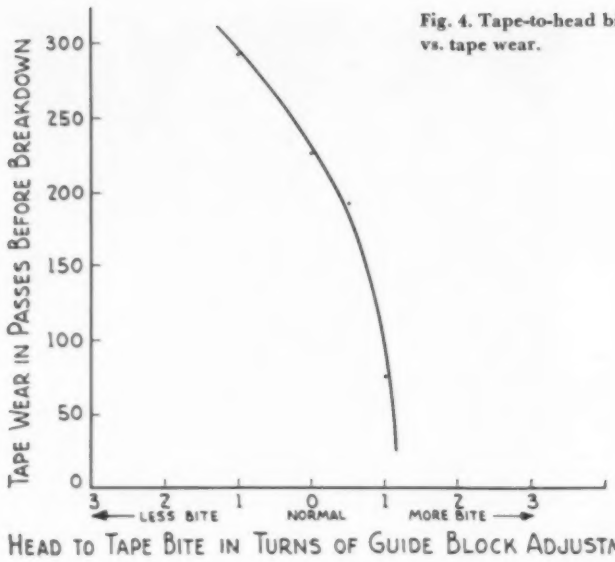

Fig. 4. Tape-to-head bite vs. tape wear.

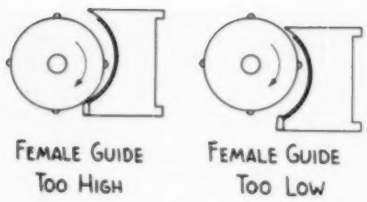

Fig. 5. Misalignment of female tape guide.

by a special technique and reveal as dark areas any valleys or holes in the coating which are deeper than about 10 μin. Note that in the photo on the left, showing the surface irregularities of typical sound-recording tape, only a small portion of the tape area is effective in recording video signals. The photo on the right, showing the surface of production video-recording tape, reveals a surprisingly high proportion of usable tape area. A commensurate improvement in noise level is apparent on the television screen.

Wear and Friction Problems

However, particle orientation and surface smoothness alone do not complete the story. Equally important is the ability of the tape to maintain its smooth surface throughout hundreds of passes through the Ampex recorder. It was soon discovered that the Ampex high-speed rotating head presented more severe wear and friction problems than ever before encountered. Early tape constructions were often gouged and scored to the point of uselessness in only one or two passes through the machine. The high head speed of about 100 miles/hr (in laymen's units) and severe head pressure of several hundred pounds per square inch created havoc with the soft binder resins used in tape coatings. These often melted and collected in hard slivers on the surface of the tape and heads. When lodged on a head, this caused "banding," or loss of every fourth "band" of 16 lines on the TV screen. When the slivers became attached to the tape surface as shown in Fig. 3, the result was a severe dropout or white flash on the television screen. These "dropouts" were then more or less permanent for the life of that particular tape, and when the number of accumulated dropouts became too great, the tape had to be discarded.

Fortunately, a great deal of work had already been done on hard wear-resistant coatings for magnetic tape, and it was possible to develop a formulation which worked. It required, however, that several dozen different runs of experimental tapes be manufactured on production equipment and evaluated on Ampex machines, and without the generous cooperation of CBS network engineers in testing these experimental tapes, this phase of the tape development might have been seriously delayed.

While the present production videotape construction is remarkably resistant to wear and friction from the rotating head, it is not completely immune. With repeated use, the tape surface is eventually broken down, after which the number of dropouts increase rapidly with each playing. However, the exact number of passes through the machine before breakdown is influenced greatly by the adjustment of the head "bite" (which controls the pressure of the heads against the tape). In one laboratory-controlled experiment, the wear life of a tape was determined as a function of the head bite with the results as shown in Fig. 4. It can be seen that a change in head bite of only 0.002 in. can make the difference between obtaining about 300 plays and only 65 plays. Tape wear is therefore an important consideration in establishing the correct adjustment of the female tape guide with relation to the rotating head assembly.

Equally important is the adjustment of the female tape guide in vertical plane as illustrated in Fig. 5. If the center of the female guide curvature and the axis of the head drum are not the same height, the head pressure will be greater at one edge of the tape than the other. The head pressure must then be increased until even at the lowest side of the tape it is sufficient to maintain a steady signal. The pressure on the high side is then excessive, and the tape will wear out rapidly along one edge. Tests indicate that the correct head setting determined from the standpoint of tape wear also yields minimum noise. This is illustrated by the curve of Fig. 6.

While the above discussion is applicable to tape wear life under controlled conditions, the situation may be modified by other considerations. Splices and dents in the tape backing create local areas of high head pressure which may result in rapid wear. In almost all cases, the end point in the life of a tape is determined by excessive dropouts.

As has been mentioned earlier, a

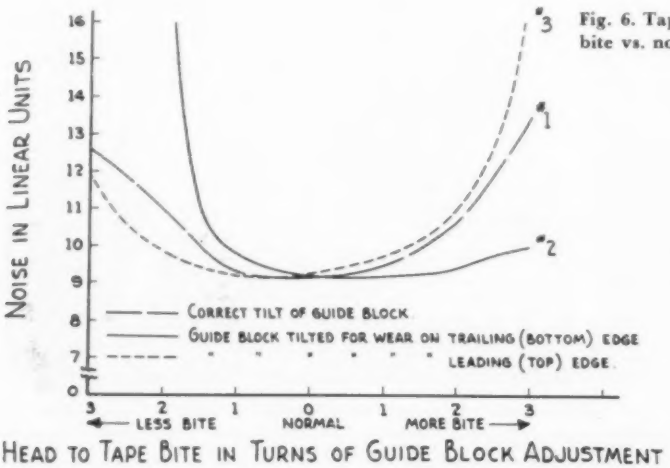

Fig. 6. Tape-to-head bite vs. noise.

smooth-surface magnetic coating is of paramount importance in preserving the quality of the video signal. In addition to average smoothness, one must also be concerned with a host of sporadic disturbances, such as streaks, scratches, nodules, dust, dents, creases and poor splices, any of which, if allowed to occur in the tape, would probably cause a beautiful pyrotechnic display on the TV screen. Unfortunately, the beauty of this is not appreciated by the networks and elaborate quality control methods are practiced in the factory in an effort to eliminate these defects. Considerable progress has been made since the first production runs of video-recording tape, and efforts to increase the already high standards of perfection achieved in video-recording tape are continuing. The difficulty of this problem can be appreciated when one realizes that a single roll of video-recording tape has an area as large as a tennis court and we are looking for flaws much smaller than a grain of sand.

As a bit of diversion from the half-hidden and microscopic problems discussed thus far, one perfectly obvious mechanical problem presented itself. In the Ampex machine an attempt is made to direct the tape through the various head stations and rollers by means of edge guiding. Any slight misalignment in the machine guiding or curvature to the tape causes a tendency for the tape to wander up or down between the guides. The 2-in. wide 1-mil Mylar base tape is not stiff enough to edge guide, but will fold or buckle. This causes loss of signal from the audio or control tracks, and in severe cases the tape creases and bunches in going through the capstan pinch. While everyone agrees that there is a tape-guiding problem, it is often difficult to know where machine alignment leaves off and tape curvature begins. Unfortunately, the factors which contribute to tape curvature are inherent in the Mylar base, and the only solution, for the moment, is to reject rolls which exhibit this tendency. Rigid quality control has all but eliminated this as a problem in the field.

In spite of the considerable number of problems encountered in the development of video tape, manufacture and use of this product are going ahead on a commercial basis. As there is almost zero margin for error in each of several dozen manufacturing steps, over 50% of the output is rejected as not meeting quality standards. However, laboratory and production research are continuing in an effort to improve both the performance and reliability of video-recording tape.

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Discussion on Video-Tape Recording

Chairman and Moderator

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Mr. Harmon: Many in our audience are a great deal more familiar with film than they are with the peculiar waveshapes that the speakers have been discussing this evening, but, speaking as a broadcaster with a little more familiarity with the electrical waveshapes than with film, I should say that Ampex, particularly on this project, has gone far off the beaten path in solving some very substantial problems in a unique way to make a major contribution to the television industry.

(*Anon*): The great tolerance of a television signal in its video portion is amazing, compared with its complete intolerance in its synchronizing portion. Why is it that we don't see more of the apparent degradation of the video part of the signal? Does it have degradation in that area?

Mr. Dolby: There is, of course, degradation of the picture as well as sync, but the effect of raw VTR signal on a stabilizing amplifier is by no means indicative of the real degradation. By comparison, a normal television receiver, which is designed to accept a certain degree of noise in the sync, would give a very fine-looking picture from direct VTR output. However, the integration action of the oscilloscope and film does give an exaggerated appearance to the noise seen in the illustrations. In fact, many picture lines may go by before a single spurious pulse appears in the VTR output.

Mr. Lewin: What success has there been in re-recording of video signals?

Mr. Ginsburg: The re-recording has been very satisfactory. The last one I saw performed in the field was about four months ago and involved a loss of about 50 lines in resolution and very little loss in signal-to-noise ratio. As a matter of fact, I have been told that, in one case, master control at CBS Television City, in selecting the better-looking tape from the output of two machines, selected the one which was actually a dub of the other. This situation occurred as a result of someone forgetting to push the record button when supposedly recording the show in duplicate, after which they made a dub of the original to use for back-up during playback.

Mr. Newmayer: In kinescoping, making a film of the video tape, do you run into any complications other than banding and shutter block which you'd get from an ordinary program? Is there any distortion that would be induced through the equipment or the frequency?

Mr. Ginsburg: No, there are no complications introduced in the process of making a film from video tape.

Mr. Zambuto: With regard to the linearity of the demodulation characteristic, is that curve theoretically derived from the assumption that your pulses, in other words your modulated waves, are actually square waves?

Mr. Anderson: No, that theoretical curve was drawn with or direct from sine-wave operation.

This discussion was held on April 29, 1958, during the Society's Convention in Washington, D.C.

Mr. Zambuto: Did you check what happens if the wave is square?

Mr. Anderson: Well, it usually ends up being a sine-wave anyhow, because of the upper cutoff frequency.

Mr. Zambuto: In the matter of splicing, it is quite evident, of course, that in the region of the butt-weld you are going to exceed the curie point. What happens there?

Mr. Machein: It is very important to determine this point of temperature and, of course, it will largely depend on the backing you are going to use. Up to this point we have been concentrating on basic questions of how to cut and splice so we are not in a position to present a final solution to this question right now. We have a welding machine ordered and in development, but it's a little bit early to give you a final answer backed by numbers at this point.

Mr. Harmon: I believe Mr. Ginsburg said that there is considerable hope that the voltage which could be read off the tape would be greatly increased at some later date because of improvements on the tape or improvements in the heads or some other mechanism. May I ask him to comment?

Mr. Ginsburg: I don't think I mentioned the tape in this connection. The tape manufacturers are doing very well, but there is lots of room for improvement in the efficiency of the heads.

Mr. Lewin: In regard to splicing, what do you do about the displacement between the sound and the picture?

Mr. Machein: The displacement between sound and picture is a constant displacement and it is somewhat similar to the displacement that occurs on film. I must admit I haven't thought of this as very serious because it's an established technique as far as motion pictures are concerned.

Mr. Lewin: If you make a cut at a certain picture frame don't you lose the sound which is in advance of that? You are dealing with a single system here and not the conventional double system.

Mr. Machein: Preferably you will choose a point for cutting your picture which is either on the end of a scene or where the sound is not significant; or you would have to find a way to delay the sound.

Mr. Smith: What physical tolerances are allowable in splicing during the vertical blanking interval? If I understand correctly, you splice between the track where the vertical blanking begins and the track where the vertical blanking ends, is that correct?

Mr. Machein: That's correct.

Mr. Smith: What tolerances do you allow in the actual "cut" between the tracks?

Mr. Machein: We must assume that the front portion of the vertical blanking will be held constant by the positioning servo and that the spacing between two tracks is 5 mils. In relation to the longitudinal motion of the tape, we found that an accuracy of ± 1 mil is sufficient. It may be interesting to note that we have made quite a number of splices, with conditions as severe as possible, making observations with the naked eye and using a razor blade. Five out of seven splices went through very satisfactorily.

Mr. Fine: How much azimuth error is tolerable in the heads of your different machines for optimum reproduction, between two machines?

Mr. Ginsburg: In considering all the tolerances that we have to meet in order to play tapes back interchangeably, it turns out that the azimuth alignment is a minor problem.

Mr. Harmon: What happens if this azimuth alignment is out? I assume that it would first appear as a difference in level coming out of the individual heads, but is there also a phase problem, a timing problem if this is out in that direction also?

Mr. Ginsburg: The phasing problem would not be of significant importance, the primary consideration being visibility of banding noise. This effect would be the result of the azimuth alignment on a given channel on the playback machine being different from the azimuth alignment of the corresponding channel on the record machine.

Mr. Harmon: As I understand it, there is a device which adjusts the gain from each head. You have separate pickup channels so that this might be taken care of if it was constant. On the other hand, if it was random it would be difficult to handle such a problem.

Mr. Ginsburg: The use of an FM system allows us to pass the recovered modulated wave through rather conventional amplifier and limiter stages. Therefore, variations in the amplitude of the r-f signal will not result in variations of the demodulated signal amplitude but merely in variations of the signal-to-noise ratio.

Mr. Hughes: In the recording of a composite NTSC signal, would this azimuth error in position between successive heads become more critical or do I misunderstand some of the physics involved? Is azimuth error allowable between successive heads?

Mr. Ginsburg: "Azimuth alignment" refers to that alignment which makes the gap perpendicular to the plane of rotation.

Mr. Hughes: I perhaps misunderstood the word. I meant the position of the heads on the periphery of the drum, at 90° intervals, 90° plus or minus how much?

Mr. Ginsburg: The positioning you are referring to is what we call angularity, or rotational alignment.

Mr. Harmon: On this delay-line detector, can you give us some information on its sensitivity and its noise level, signal-to-noise and such characteristics? It certainly is admirably simple. What are these characteristics in terms of some of our other types of detectors for FM signals?

Mr. Anderson: I must confess I don't remember all those figures. I do know the conversion sensitivity was quite a bit better than we had found in the slope detector. This made it a very attractive type of translation device, but I don't remember all of the signal-to-noise figures and the conversion factors.

Mr. Harmon: Certainly it's simplicity in itself.

Mr. Anderson: Yes, and nothing to go wrong, very straightforward.

Mr. Zambuto: I can conceive of at least two different types of flutter possible in this machine because of the two different motions. Can you give any idea of the tolerances in that?

Mr. Ginsburg: We can eliminate the factor of longitudinal tape flutter. This has primary bearing only on the audio track performance. Hence, it is simply necessary to conform to high-quality audio-tape recording tolerances.

Mr. Zambuto: Wouldn't that also affect the relative signal level because it would displace the rotating head with respect to its own track, so the head wouldn't read the whole of the track but only a part of it?

Mr. Ginsburg: No, by the time the flutter in the longitudinal direction gets that bad, the audio is so bad that you wouldn't want to use the tape anyway. Errors in the time base characteristic of a program played back from tape are, to a very large extent, a function of the oscillations of the rotating drum about its proper time varying position. For the usual case in which drum displacements take place in a sinusoidal fashion, it is desirable to keep F squared times A equal to or less than 3, where F is the natural hunting frequency and A is the peak amplitude of the displacement expressed in rotational degrees.

Mr. Zambuto: With respect to the future uses of this device, it has been said that possibly it could be mounted on a truck for recording certain events. Exactly how portable do you think this equipment is at the present moment?

Mr. Anderson: The best answer I can give to that is the fact that I said, "a truck." The equipment weighs, if I'm not mistaken, about 1350 lb and it does require a lot of portable space and portable power to move it around.

Mr. Zambuto: I wasn't thinking just in terms of power, I was thinking in terms of what may happen to the equipment during transportation. In other words, what kind of shock isolation should the equipment be given and do you think this would be feasible? What transportation difficulties would you expect?

Mr. Anderson: The original piece of equipment that was shown last year at the NARTB was self-contained in one console. It was taken out of the console to make it more accessible to the broadcaster. As a measure of the reliability and desirability of the equipment, that particular recorder was shipped to Chicago by truck from the airport, bounced on a DC-6 all the way back and I'm sure it was pushed off the DC-6 on to a truck and then back to Redwood City. That same equipment was trucked again to Los Angeles, trucked to Monterey, and I think it's been trucked around the Bay area several times. As far as I know, no damage has ever resulted from any of those operations.

Mr. Solow: Mr. Miner said that he wanted to elicit some comments from the audience, so it is perhaps fitting that I stand up here and let these evil geniuses look upon the kind of human being they're going to render extinct in the near future. In my opinion, the real impact of videotape recording on television will come through programming, as Mr. Miner suggested, rather than through a straight technological competition with film. In this respect, video tape is different from the introduction of audio tape in radio because in that instance there was a contest between recorded and live radio programs, whereas now video tape represents really the live technique versus a film recorded show. I fear, on behalf of my own welfare, that video tape will change programming to the extent that film will be used less, because

live TV is not very popular with actors and actresses. In the half-hour and hour presentations in the live form, all sorts of tensions, frantic costume changes and scene changes are, of course, necessary and, as a result, many actors and actresses refuse to appear on live TV. Of course, the tension arises from the fact that a fluffed line is going to be heard by the entire audience, or some disarray in the dress of a male actor who has just made a quick change may be evident. So, even without any further perfection in the technique of splicing, isn't recording in segments — starting with a fade-in and ending with a fade-out — possible, so that an hour's show can be leisurely performed in front of television cameras, together with a video-tape recorder, in perhaps the space of 6 or 7 hours preceding the broadcast. Then everybody can go home, relax and look at the show on the air and it will, essentially, be a live show. In this way your video tape will enhance the ease of presentation of live TV and render film shows less necessary as time goes on.

Mr. Harmon: One thing that would bother me about this, in what you say, in going to "black" as we call it, in television, this is fine, but suppose you have a fluff in the middle of a television field, how do you splice this?

Mr. Solow: Do it over again. Do it in easy segments.

Mr. Harmon: But you're still going to have to go back to a vertical period somewhere to make the splice?

Mr. Solow: That's right. You'd divide an hour's show perhaps into six 10-min segments.

Mr. Harmon: I thought you might be suggesting to the Ampex gentlemen that here's a neater way to splice, just go to black for a couple of dozen fields and cut anywhere you want and let your picture roll.

Mr. Solow: No, construct the script originally in the form of segments that would start with a fade-in and end with a fade-out, so that each segment is successively put in the can. You could then splice without worrying about revealing the scan lines, and just play the whole show. Of course, as more machines are delivered to the networks, I can also foresee, with added horror, that each television camera can have its own tape recorder connected to it, and then after all of the performance has been completed, the show can be played back over several monitors in the manner that live TV is played back, and a technical director can then punch one tape in following the other, and make lap dissolves and fades and that sort of thing. I suppose that is in the offing, too. So it's a dim future.

Mr. Miner: I think the general area that you're discussing resolves itself, in great measure, to the operating agility of the people who are using the equipment rather than the actual abilities of the equipment itself.

Interchangeability of Videotape Recorders

By CHARLES P. GINSBURG

New requirements are placed on video-tape recorders when tapes are to be recorded on one machine and reproduced on another. The nature and extent of these requirements are discussed for both monochrome and color.

Some of the greatest problems involved in the interchangeability of video tapes, whether in monochrome or color, come from the fact that the pictures from the tape are segmented. An average of a little more than 16 picture lines is read out as each head describes an arc of 90° across the tape. There are 16 of these picture line groups in a field. Because of the segmentation, small variations from one band to another in noise, in frequency response or in time position will be visible and objectionable. If we make the reasonable assumption that the response characteristics of the four r-f electronics channels which carry the signals to and from the heads are matched, the variations mentioned above can be discussed in terms of electrical and magnetic behavior and mechanical positioning of the heads.

Noise Banding and Frequency Banding as a Function of Variations in Head Performance

Let us say that the process of recording a signal on tape and then recovering it constitutes a transmission channel. On the VR-1000 Videotape Recorder, we have four such head-tape transmission channels. These channels vary among themselves in two ways of special interest to the interchangeability problem:

(1) Slight variations exist in the impedance frequency characteristics of the several channels. This is due to very small differences in head circuit resonant frequency, including variations in the source impedance of the amplifier circuits driving the heads during recording, as well as loading impedances presented to the heads during playback.

(2) Attenuation characteristics due to magnetic losses and to gap effect vary slightly from one head to the next. Since we are working with magnetic gaps whose dimensions approach the shortest wavelengths which are recorded on the tape, there may be variations in attenuation resulting from an inability to hold the gaps to exactly equal values for all heads.

Consequently, in comparing the transmission characteristics of the four channels, we will find:

(1) Differences in the amplitude vs. frequency characteristics accompanied by differences in delay distortion. This would be the case for variations caused by differences in the resonant frequencies.

(2) Differences in the amplitude versus frequency characteristics not accompanied by differences in delay distortion. This would be the case for variations caused by differences in the size of the magnetic gaps.

The tendency toward noise banding and frequency banding will increase somewhat when tapes are to be played back interchangeably. The optimizing of the recording current for a given head is, by definition, a process by which the best possible picture is obtained, and results in the best possible current setting in view of the playback as well as the record characteristics of that particular head. Theoretically, there are several reasons why an optimum recording current setting for a given head will not necessarily be the best setting if a different head assembly is to play back the same tape. Fortunately, in practice, this matter is of secondary importance.

The azimuth alignment requirement for the head gaps, i.e. perpendicularity with respect to the transverse magnetic tracks, is considerably tighter for interchangeability than it is for an operation in which a tape is to be played back only with the same head assembly with which it was recorded. Within extremely wide limits of azimuth errors, there is essentially no decrease in head resolution or head output in the latter case, since the control system is so designed that each of the four heads will play back the particular set of magnetic tracks which it recorded. However, if the azimuth is different in playback than in record,

Presented on April 24, 1958, at the Society's Convention in Los Angeles by Charles P. Ginsburg, Ampex Corp., 934 Charter St., Redwood City, Calif.
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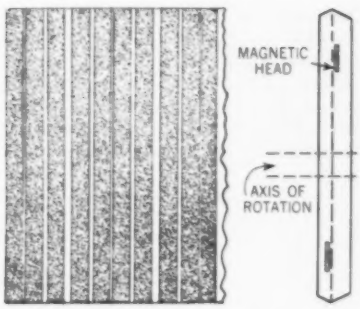


Fig. 1. Irregular track spacing.

Fig. 2. Playback result when female guide is farther from drum than when recording was made.

which would be the case in interchanging tapes, there will be a loss in playback voltage increasing at the shorter wavelengths and causing a decrease in signal-to-noise ratio even for small azimuth errors. Since we are concerned with wavelengths as short as 200 μin., the numerical value of the azimuth tolerance might be very difficult to meet were it not for the fact that the tracks in the Videotape Recorder are only 0.01 in. wide. The displacement of the axis of the gap with respect to the axis of the recorded signal must be kept small with respect to the shortest wavelength which is to be reproduced. It is obvious that this same tolerance can be met at a larger angular difference as the track width is decreased.

Because of the several sources of variation in transmission characteristics from one channel to the next, it might seem desirable to have independent control of the r-f playback response of each of the four channels. However, from an operational standpoint, it is highly desirable to be able to play back a tape recorded on a different machine without adjusting the channel response characteristics. The heads have been sufficiently well controlled in performance to permit the interchange of monochrome tapes without playback equalizing controls, but because the high-frequency components of the NTSC color signal are more important than they are in monochrome such adjustments are usually necessary when interchanging color recordings.

Another source of degradation of signal-to-noise ratio peculiar to the interchangeable use of video-tape recordings lies in the mechanical tolerances affecting the pattern written on the magnetic tape. As shown in Fig. 1, errors in track spacing can be caused by faults in positioning the heads in the axial direction. Somewhat similar troubles can be caused by excessive wobble of the rotating head drum, or by asymmetry with respect to the center line of the tape as the tape is guided from the supply reel to the head drum and then to the take-up reel.

When a tape is played back on the same machine and with the same head assembly with which it was recorded, these track spacing and track curvature problems are of little or no importance, since eccentricities in recording will be followed by the same eccentricities in playback.

For operations in which tapes are used interchangeably, however, a misregistration of as little as 0.002 in. during part or all of the sweep of a given head across the tape will result in a decrease of the amplitude of the recovered modulated wave, a consequent decrease in signal-to-noise ratio for the corresponding portion of the reproduced picture, and an increase in banding noise.

In short, slight tracking errors will merely result in an overall decrease of the signal-to-noise ratio for the non-interchanged tape playback; but these same slight tracking errors will cause banding noise in the tape interchange case if track spacing or track curvature errors exist. For an overall signal-to-noise ratio of 36 db, for example, a difference of 2 db from one band to the next will be more objectionable than an overall degradation of 2 db.

Time-Base Banding

If the timing variations in the reproduced picture which may occur as a result of variations in the rotational motion of the drum are disregarded, the factors which play a role in the variations in time position of the information coming from the rotating heads can then be classified as:

(1) Factors relating to the positioning of the head tips around the circumference of the drum. This positioning is referred to as rotational alignment, or angularity, or quadrature relationship.

(2) Factors involved in the configuration of the drum and the female guide.

Angularity

If the time base of the reproduced information experiences a discontinuity in the transition from the output of one head to the output of the next, there will be a corresponding step in the picture information which appears on the monitor. Figure 2 shows such discontinuities generated when the female guide in playback is farther from the drum than it was when the recording was made. Figure 3 illustrates what happens when a tape is recorded by heads in proper rotational alignment but which is being played back by heads which are not in quadrature.

Although the FCC standards of good engineering practice imply that such discontinuities must not amount to more than 0.5% of the line period, or about 0.3 μsec, an error this large repeated every 16 picture lines is intolerable to the observer. To hold these displacements to an acceptable value, each head gap should be positioned to within one-half the distance on the drum circumference corresponding to 0.05 μsec, since the error will be cumulative when the tapes are used interchangeably. In linear distance on the drum, this amounts to about 38 μin.

Since it would have been impractical to use optical means for rotational alignment of the heads on the periphery of the drum, it was initially planned to use delay lines to compensate for errors

Fig. 3. Result of poor quadrature alignment.

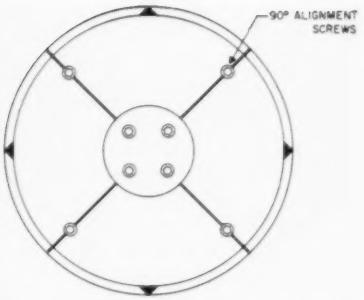


Fig. 4. Arrangement of alignment screws.

in angularity. However, because of problems resulting from interchannel cross-talk during both record and playback, and also because of some possible operational complications, it was decided instead to use an approach in which the heads are first aligned on the drum to within 1 μsec, and are then brought into effectively perfect angularity by means shown in Fig. 4. The tapered alignment screws are used as vernier angular adjustments of the pie-shaped segments of the drum, and angularity of the head gaps can thus be set to a very precise degree.

Head Wear, Tape Stretch, and Nonconcentricity

For color as well as for monochrome, we are concerned with changes which occur as the pole tips of the rotating heads wear down due to abrasion by the tape. The nominal setting of the female guide for a new head drum assembly is approximately that setting which establishes concentricity of guide profile and drum (Fig. 5).

There is sufficient tension exerted on the tape from both lateral directions so that the rotating head tips which project from the periphery of the drum into the slot in the female guide actually stretch the tape temporarily in the region of head contact. It is obvious that as the guide is moved closer to the drum, the extent to which the tape is stretched at any given point in the sweep is increased in accordance with the movement.

Assuming that a recording has been made and then put on the shelf while the heads are worn down 0.001 in. through usage, what happens when an attempt is made to play back the old recording?

Having a smaller sweep radius, each head gap will now describe a shorter path per unit angle of sweep. On the other hand, the tape is now being stretched less, and thus the information that was recorded per microsecond will tend to have a shorter path during the playback process than it occupied during the original recording process. In practice this compensating action is about 90% effective, which means that for 1 mil of tip wear the guide must be backed 0.1 mil away from the drum.

Although there are means by which

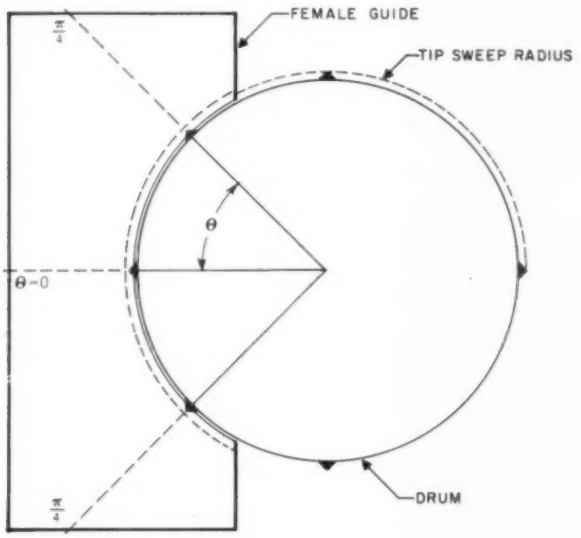


Fig. 5. Profile of drum and guide.

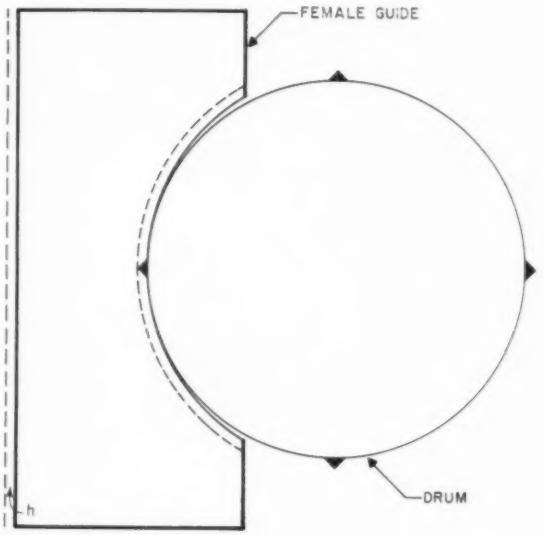


Fig. 6. Nonconcentricity due to movement of guide toward drum.

Fig. 7. Scalloping distortion resulting from vertical misadjustment of the guide.

this percentage of compensation might be increased to the point where no adjustment of the guide would be needed, there are other considerations which require that a compensating means be available by which to alter the time base of the playback signal. For example, the temperature and humidity coefficients of the tape itself are large enough to necessitate time-base adjustment even under fairly limited ranges of ambient conditions. The range of compensating movement of the female guide may be expected to be greater under conditions of interchanging tapes from one recorder to another than it would be in the case of recording and playing back on the same machine.

Since the curvature of the guide and the arc of the rotating heads can be concentric at only one horizontal position of the guide with respect to the drum, it is apparent that the geometry will generally display some small nonconcentricities (Fig. 6). Consequently, we can expect variations in the extent to which the tips protrude into the guide slot, with accompanying changes in tape stretching, as a function of the instantaneous angular position of a given head. Therefore, it becomes necessary to ascertain:

(1) What effect on raster structure is generated by these variations?

(2) What effect on color signals is created by these nonconcentricities?

Some simplifications can be effected by assuming that perfect recordings have been made in every case and that any changes in position or dimension are understood to prevail only during playback. Let ΔP be the change in protrusion of the head tips into the guide slot, and consequently into the tape, as a result of a change in the guide position with respect to the drum. Θ is the angle which a given head makes with respect to a horizontal line directed from the drum center toward the guide. The heads sweep down across the tape so that Θ for the active part of the head sweep starts off at $-\pi/4$, progresses to zero and then to $\pi/4$. For a horizontal movement, h, of the guide toward the drum, $\Delta P = h \cos \Theta$.

Let us define a function ΔS as the proportional difference between playback time base and record time base. This might best be explained by the following example: If a given amount of picture information took 10 μsec to record, and then, because of a horizontal movement of the guide, takes 10.5 μsec to play back, ΔS will be equal to 0.05. This means that the playback time base will have a proportional difference of 0.05 with respect to the record time base. Thus ΔS is dimensionless and is merely a correction factor to apply in the case of a misadjustment, misalignment or compensating movement.

We can now set

$$\Delta S = \frac{Kh \cos \Theta}{r}$$

where r is the tip sweep radius and K is the numerical value of the compensating action referred to earlier; i.e., small tip radius changes are 90% compensated for by a decrease in tape stretch.

If we define e as the total accumulated error in time base as the head describes an arc between two values of Θ, then

$$e = \int_{\theta_1}^{\theta_2} \Delta S d\Theta = \frac{Kh}{r} \int_{\theta_1}^{\theta_2} \cos \Theta d\Theta$$

If we want to predict the extent of the discontinuity generated by moving the guide 1 mil closer to the drum, we have merely to integrate e over the limits of $\pi/4$ to $-\pi/4$. Thus,

$$e = \frac{Kh}{r} \int_{-\pi/4}^{\pi/4} \cos \Theta d\Theta$$

$$= \frac{0.9 \times 0.001 \times 1.414}{1.036}$$

$$= 1.23 \times 10^{-3}$$

Therefore, the amount of information recovered by a head during its 90° arc is less than it should be by a factor of

Fig. 8. An example of successful interchangeability, when components are properly adjusted.

1.23×10^{-3}. Since it takes 1/960th of a second for a head to describe a 90° arc, the accumulated time-base error during the sweep amounts to $1/960 \times 1.23 \times 10^{-3}$ seconds which equals approximately 1.3 μsec.

The type of scalloping distortion shown in Fig. 7 is the result of vertical misadjustment of the guide. The fact that such distortion is accompanied by negligible displacement at the transition points can be shown by integrating the cumulative error e over the range defined by the active portion of the head sweep. For a vertical guide misalignment v, $\Delta S = \frac{Kv}{r} \sin \Theta$, and therefore:

$$e = \frac{Kv}{r} \int_{-\pi/4}^{\pi/4} \sin \Theta d\Theta = 0$$

Thus the total amount of information played back under conditions of vertical mispositioning of the guide is correct, although time-base errors within each head sweep may easily reach an objectionable value. If we define scalloping as the accumulated time error between $\Theta = 0$ and $\Theta = \pi/4$, then scalloping equals:

$$\frac{1}{2 \times 960} \int_0^{\pi/4} \Delta S d\Theta = \frac{Kv}{1920} \int_0^{\pi/4} \sin \Theta d\Theta$$

For a vertical misalignment $v = 0.1$ mil, the scalloping will thus amount to less than 0.015 μsec within each band. The maximum tolerable amount of scalloping, from the standpoint of subjective picture quality, may be considered to be 0.1 μsec or less. Proper adjustment of vertical positioning of the guide prior to recording can be made by use of a standard alignment tape.

Finally, let us consider the effects, on a color picture, of the nonlinear characteristic induced in the time base by the nonconcentricity which results from guide movement. Since the color system is one in which phase locking is effected at the beginning of each picture line, our principal concern is the extent to which phase shift occurs at the 3.58 mc subcarrier frequency during a single line. We have considered time-base errors caused by nonconcentricity to be sinusoidal. Vertical misalignment of the guide with respect to the drum will cause an expansion of the time base at one extreme of the sweep and a contraction of the time base at the other extreme. This will be accompanied by a maximum rate of change of the time base occurring during that television picture line which is read out at the center of the sweep. A horizontal mispositioning of the guide will result in a maximum stretch error at the center of the sweep and a maximum rate of change of time-base error during the first and last lines of each sweep. The extent of the time-base rate errors will directly determine the amount of hue shift in a burst locked color Videotape Recorder system. Taking into account all of the variables involved in a given playback operation, and even allowing a reasonable degree of operational or setup error, the worst case of phase change within one line will be undetectable to the eye.

Since time-base distortions of the type we have been discussing can be closely controlled, especially as operating and maintenance characteristics of the machines continually become better understood by the users, it seems rather doubtful that these phase changes will ever become objectionable. However, if the expanded use of color video-tape recorders on an interchangeable basis, involving sequential duplication operations, presents detectable hue shift in the picture, the problem can be readily solved by the use of a pilot carrier system of the type which has been developed in the laboratory and which grants complete freedom from the type of defects discussed. The conversion of color machines from burst locked to pilot carrier operation would be a comparatively simple matter. Unless we find that eventual usage warrants the transition to a pilot carrier system, it is best to reserve that portion of the video-tape spectrum for other possible uses.

Discussion of Video-Tape Recorder Operations

Seven speakers presented these subjects at the Society's Convention in Los Angeles on April 24, 1958:

"Magnetic Tape for Video Recording" by ROBERT A. VON BEHREN, Minnesota Mining and Mfg. Co., 900 Bush St., St. Paul 6, Minn.

"Engineering Planning in the Evolutionary Development of the Video-Tape Recorder" by JOHN M. LESLIE, JR., Ampex Corp., 934 Charter St., Redwood City, Calif.

"Electronic Marking and Control for Rapid Location of Vertical Blanking Area for Editing Video-Tape Recordings" by JOSEPH ROIZEN, Ampex Corp., 934 Charter St., Redwood City, Calif.

"Electronic Convention to Color Recording With the Ampex VR-1000 Video-Tape Recorder" by CHARLES E. ANDERSON, Ampex Corp., 934 Charter St., Redwood City, Calif.

"Timing and Frequency Requirements for Color Video-Tape Recording" by EARL ROGER HIBBARD, Ampex Corp., 934 Charter St., Redwood City, Calif.

"Interchangeability of Color Video-Tape Recordings" by CHARLES P. GINSBURG, Ampex Corp., Redwood City, Calif.

"Magnetic-Tape Recording of Color Television Signals" by JEROME L. GREVER, Radio Corp. of America, Camden, N.J.

Other participants in the discussion which followed the group of papers were:

RALPH E. LOVELL (Session Chairman), National Broadcasting Co., 3000 West Alameda Ave., Burbank, Calif.

GEORGE LEWIN, Army Pictorial Center, 35-11 35th Ave., Long Island City, 1, N.Y.

J. BARRY WATKINSON, Cascade Broadcasting Co., P.O. Box 702, Yakima, Wash.

RALPH R. WELLS, Columbia Pictures Corp., 1438 N. Gower St., Hollywood.

WALTER BACH, Berndt-Bach Inc., 6900 Romaine St., Hollywood 38.

RALPH DODDS, Creative Productions, P.O. Box 765, Burbank, Calif.

ROLF A. SEITLE, KQED, 525 Fourth St., San Francisco, Calif.

HELMER W. ANDERSEN, CBS Television, 6121 Sunset Blvd., Los Angeles.

DAVID S. HORSLEY, 3929 Kentucky Dr., Hollywood 28.

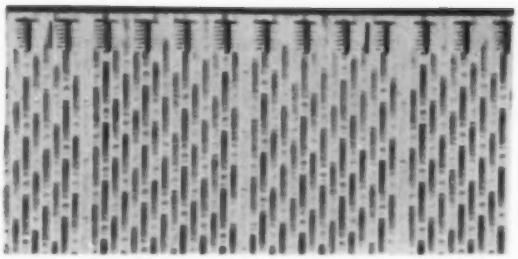
ROBERT G. NEUHAUSER, Radio Corp. of America, Lancaster, Pa.

Mr. Lewin: Is there any hope of interchangeability between the RCA and Ampex recording?

Mr. Ginsburg: Ampex and RCA recognize the importance to the industry of establishing interchangeability between the video-tape recorders of both companies. Steps are being taken to agree on various system parameters so that such interchangeability can be brought about.

Mr. Lewin: In view of the rather high cost of the video tape, is there any hope of re-using the tape once it's been spliced?

Mr. Roizen: Yes, although it requires a little skill to splice together two tapes from different machines so that they will go through without showing any discontinuity in either the sync or video information. If you record over the splice you wouldn't even know it went through the machine. In other words, if you erase the tape and re-



Edge of 2-in. RCA video tape with two edit pulses.

record, you never know the splice is there because the condition of recording and playback then becomes the same.

Mr. Lewin: There is not enough distortion occurring at the splice point to cause even a little disturbance?

Mr. Roizen: No, because the splice point consists of $\frac{1}{4}$ in. of backing tape. That quarter inch represents 1/60 of a second of picture information so it would take an eagle eye, if the picture did not roll, to even notice that it went through. If you hooked up an oscilloscope with a delay circuit, etc., and caught it at the right moment you could tell a slight difference, but beyond that there's nothing that you can see in a re-recorded tape after the splice has been made.

Mr. Lewin: It's a little hard to reconcile that with experience in audio recording where invariably a little "bloop" due to the splice will be heard.

Mr. Roizen: If you record over a piece of audio tape that has been spliced together, do you hear the splice go through?

Mr. Lewin: If you put a continuous tone over a splice you'll certainly get a little "bloop."

Mr. Roizen: Yes, but I suppose it's as difficult to sell tapes with continuous tones as it is for us to sell monoscope patterns that we use all the time to show the deficiencies of our picture.

Mr. Lewin: But you do have to record continuous tones.

Mr. Roizen: Well yes, I realize this, but I think it's a matter of minor importance to video tape. We certainly don't throw away tapes after we cut them apart, they are too expensive!

Mr. Watkinson: I have seen those maladjusted monoscope patterns many times but never had it explained whether they were made with a monitor with a free running horizontal oscillator or with a horizontal oscillator that was trying to remain in sync.

Mr. Ginsburg: Those pictures were all made using Conrac monitors with standard time constants. In relation to the repetition rate of the discontinuities generated by moving the female guide, the monitor time constant may be considered infinitely long. No distortion of the displacement patterns is caused by the time constant being too short.

Mr. Watkinson: That's what I was curious about—some monitors would tend to follow that.

Mr. Ginsburg: That would be true only in the case of a monitor with no AFC. Virtually all station monitors and home receivers would ignore the discontinuities. In other words, the discontinuities would not be minimized by the time constants in the monitors or receivers.

Mr. Wells: One paper carefully described the insertion of pulses so that the tape can be spliced. Does the RCA system have something like that?

Mr. Grever: We have a slightly different system but it's basically the same. You will recall that the control track was a series of little horizontal lines; actually those are the back edge of the sawtooth, at a 240-cycle rate. Every half an inch there was one frame pulse, this being slightly different from the Ampex system which has pulses every quarter inch, every field. The pulses on that particular slide I showed were every $\frac{1}{2}$ in. or every frame.

Mr. Wells: Are they similar to the Ampex in that they have a much higher amplitude so that they'll show in the horizontal?

Mr. Grever: No, in this case you see a regular spaced line horizontally, and you look for a Roman numeral III, you might say, because every half an inch there's an extra line right in the middle between two other lines and they stand out as little groups of three. You position the frame mark in the splicer in such a way that the cut is made in the vertical blanking interval.

Mr. Lovell: In view of the interest in this subject would it be possible to show that slide? There's a great deal of interest in the subject of editing and it warrants just a little further attention.

Mr. Grever: Now (referring to the illustration) there can be seen: the vertical blanking, a 240-cycle pulse, and the little "three" that I talked about. It may not be too sharp in this particular photograph, but this one is displaced an exact distance from this track. A cutter, who would use an optical principle to center over the pulse, would cut right through the tracks containing the vertical blanking interval.

Mr. Lovell: The displacement between the soundtrack and the picture heads is $9\frac{1}{4}$ in. It is felt by some editors that this is much too great a distance for editing successfully. For example, in editing on sound there will be $9\frac{1}{4}$ unwanted inches of picture. Is there any likelihood of moving the audio closer to the video head?

Mr. Roizen: This is a problem that everybody who comes to the plant asks about. Most network people have pointed it out in the past, and here again some of the parameters of the operation of the tape come into play. Nine and a quarter inches may seem like a long way, but it's actually only $\frac{1}{2}$ sec of tape time. Only under very stringent picture and sound conditions would there be a problem. For example, a gunshot, which must occur at a specific time, has a very short sound in relation to the picture. The cut must be at the end of the gunshot as far as the sound goes. There are problems but probably no worse than present film problems when the sound is ahead of the picture and film. There is an advantage in the video-tape recorder in that it is possible to erase the sound and redub it easily by shuttling the tape through the machine. In the case of the gunshot, it would be no trouble at all to move it back, just a bit, and have the picture come out right. I think this is a problem of technique. The man twirling the reels back and forth and listening for the right point will usually find enough picture material and enough sound to cut where it will work out right. We've discussed this frequently and have not yet arrived at a completely satisfactory answer.

Mr. Lewin: The difference seems chiefly that in motion-picture production you do not edit single-system film, which has the sound displaced forward, as you have in this medium; you edit double-system, which means you can cut picture and track any place you like. Once you've done that, then you make a composite print.

Mr. Bach: In editing film magnetics on a combination of picture and soundtracks, we have developed a means of sliding the soundtrack forward and back without the use of any storage devices and without introducing any motion troubles. These techniques could just as well be used on this other problem. You could slide the sound adjacent to the picture and then edit straight across and, after putting the picture together, you could slide the sound back to be in advance of the picture, wherever you wanted it to be.

Mr. Lovell: That technique is a very interesting one. With the appropriate line-up of a magnetic record head, erase head and playback head, plus the addition of some simple audio switching, it is possible to move the sound back so that it is opposite the picture, then edit it as has been indicated—in the dead sync condition—to use film terminology, then move the sound ahead again to its original position. I don't know of anyone who is doing this but it is an interesting possibility.

Mr. Dodds: If this displaced system can possibly be changed so that we can simultaneously record picture and sound in the same spot, it should certainly be looked into.

Mr. Seitle: Concerning the female guide and the adjustment that controls the distance of tape in relation to the head assembly, for the rotating head assembly, in the case of color I can now understand that this may be a necessary operational adjustment, but could not this be made fixed for monochrome? In other words, the distance of the female guide assembly cannot be changed. Its radius can be changed on the prototypes. I've seen also many tapes being chewed up by a misadjustment of that and it could possibly be fixed as the tapes are uniform.

Mr. Ginsburg: The key to keeping the total required adjustment range of the female guide as small as possible lies in getting into the field properly designed alignment tapes so that the operators can correctly position the guide with respect to the head. Once this is done, the actual adjustment range needed for the guide is quite small, even under fairly wide variations of temperature and humidity. The adjustment needed to compensate for tip wear is very small since there is a self-compensating

change in the amount of tape stretching. The amount of guide movement required to compensate for two mils of tip wear would only amount to 0.2 mil.

Mr. Lovell: When will it be possible, or why isn't it possible, to have a monitor head arrangement following the record head, so that the signal could be seen as it plays off the tape a fraction of a second after it's been recorded? This is a common practice in audio recorders and it would be very helpful to the broadcasting people if such a monitoring head were available. It would seem that putting another similar 2-in. head on the same shaft, perhaps ½ in. away, would do the trick.

Mr. Leslie: It is certainly possible to solve the problem, but it would be uneconomical from both the manufacturer's and the customer's standpoint. The monitor head assembly would have to be located a considerable distance from the recording head assembly in order to avoid electromechanical interferences of a type that would be particularly distressing when the recordings are to be used interchangeably. The added cost for such provisions would not prove very attractive to prospective purchasers, especially in light of the proven reliability of the machines as they are now.

Mr. Grever: I would like to add that we will reduce the tape life by a factor of 2 if we do this, because every time you record you will go over it twice and every time you play back you will go over it twice so that for record and playback function you will have gone over the same area four times. It would be a serious reduction in tape life and this is a big problem

Mr. Anderson: Without being facetious, I can note that sitting through a number of shows each costing about $100,000 and up per hour and wondering if there is anything on the tape makes the problem of having the second head seem less serious.

Mr. Horsley: What is the prospect for being able to record and re-record from tape to tape as is customarily done with magnetic tapes in audio practice?

Mr. Leslie: Tape copies are used on the air every day. There is a certain amount of loss in signal-to-noise ratio and in resolution at the present time, but dubs are without question fully acceptable for broadcast use. Even copies of copies have been used on the air. Since there is always some degradation in the process of duplicating, whether audio or video, the best approach to the improvement of signal-to-noise characteristics in copies lies in improving these characteristics in the basic machine. Duplication is better now than it was some time ago and we expect it to continue to improve.

Mr. Neuhauser: We have been told about signal-to-noise ratio improvement but no figures have been given on typical signal-to-noise ratios that are capable of being achieved. What are these values?

Mr. Leslie: With the prototype machines that were delivered to the networks, the signal-to-noise ratio varied with the machines depending upon their condition at that time and the tapes that were available. The signal-to-noise ratios varied from 30 to 34 db. The method of measurement was taking peak-to-peak video with respect to rms noise. On the VR-1000 machine that we're putting out now, I believe the minimum signal-to-noise ratio is 34 db.

Mr. Lovell: In view of the lateness of the hour we will at this time bring the discussion to a close.

Ed. Note: *Plans are to publish within a very few months two or three more video-tape recording papers, chiefly about color recording.*

Improved Television Viewfinder for Motion-Picture Production

By KARL FREUND

A low-cost TV viewfinder using a 1-in. vidicon with 600-line resolution is described. An earlier version of this viewfinder which used a ½-in. vidicon with 300-line resolution was presented at the Society's 80th Convention in Los Angeles. The new viewfinder is expected to cut costs of motion-picture production by enabling the director to view a picture on a TV monitor as it is being filmed, thus aiding him in making decisions concerning re-takes.

Fig. 1. Miniature camera is 2½ in. square and 7½ in. in length.

THE BENEFITS of a device which would permit a motion-picture director to watch a picture on a TV monitor as it was being filmed have been considered by the author since the introduction of live television. At the Society's 80th Convention in Los Angeles, a converted Mitchell Viewfinder with an optical system and ½-in. vidicon closed-circuit TV camera, developed by Lockheed Aircraft Co., was introduced. The demonstration was premature in that the optical system incorporated in the viewfinder absorbed too much light and the ½-in. vidicon was not sufficiently light sensitive to compensate for the loss.

The viewfinder described in this paper represents a new approach to the problem. It was decided that the desired results would be more likely to be obtained by developing a miniature camera using a 1-in. vidicon with higher resolution than 300 lines and by-passing the optical system. It was recognized that the earlier system had the advantage of zero parallax but rather than modify existing cameras, which would be an expensive procedure,

Presented on April 24, 1958, at the Society's Convention in Los Angeles by Karl Freund, Photo Research Corp., 837 N. Cahuenga Blvd., Hollywood 38.
(This paper was received on August 7, 1958.)

Fig. 2. Monitor with framing system used in Mitchell Viewfinder.

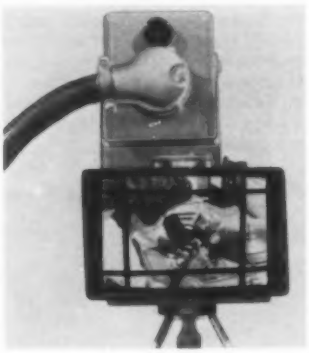


Fig. 3. Framing on TV monitor and viewfinder checked before shooting.

the new camera was designed to be mounted on top of the Mitchell Viewfinder and compensate for the vertical parallax mechanically, in the same way that the horizontal parallax is solved on the viewfinder.

This device has only one purpose, that of allowing the director to evaluate composition. It is not intended to be used in judging photographic quality.

The new camera, which was developed by Photo Research Corp. is 2½ in. square and 7½ in. in length, reproduces

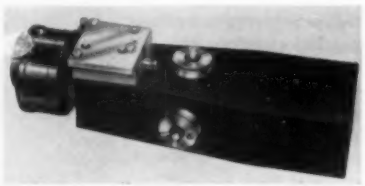


Fig. 4. Plate fastened to aluminum casting of viewfinder.

600 lines of definition at 10 ft-c. This represents double the resolution of home-type TV sets (Fig. 1). The small control unit is placed on a camera dolly. The monitor can be placed 500 to 1000 ft from the camera. Any number of monitors may be used. The system uses standard TV frequencies, i.e., 60-cycle frame rate; 15,750-cycle line rate; 525 raster lines interlaced. Power requirement is 60-cycle 115-v a-c. The camera is ruggedized for high vibration and noise environment and shock tested to 20 g.

To compensate for different lenses, the framing system used in the regular Mitchell Viewfinder was incorporated into the monitor (Fig. 2). It was found that by checking the framing between the TV monitor and the viewfinder on the camera before shooting close correlation could be achieved (Fig. 3).

Only two steps are necessary to attach the miniature camera to the viewfinder. First, a plate, which remains permanently in place, is screwed to the aluminum casting of the Mitchell Viewfinder (Fig. 4). Second, an easily removable shoe is attached to the plate (Fig. 5). The vertical parallax compensation is taken care of automatically by utilizing the focusing rod of the viewfinder (Fig. 6).

The system is economically priced and achieves the purpose of enabling a motion-picture director to see the picture he is directing on a TV monitor. It is especially useful as an aid to making decisions on re-takes when a multiple camera setup is used or when the camera is mounted on a boom. The system should also be useful in live TV productions, shooting with motion-picture cameras.

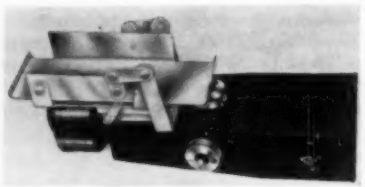


Fig. 5. Removable shoe attached to plate.

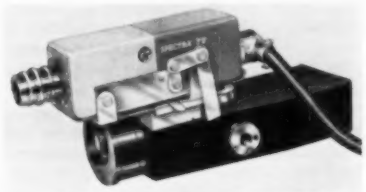


Fig. 6. Camera in place on viewfinder.

This system may also be used in underwater photography. The housing measures 4 in. by 10 in., with remote focusing adjustment.

The device is expected to afford substantial assistance in reducing the high cost of production.

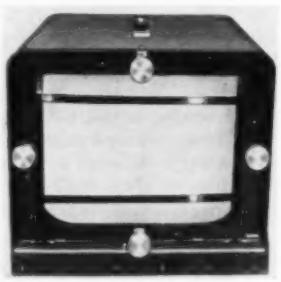


Fig. 7. Framing for CinemaScope.

Addendum

Leo Levi, "High-Fidelity Video Recording Using Ultrasonic Light Modulation," *Jour. SMPTE, 67:* 657–661, Oct. 1958. The following is information received from Mr. Bach since publication of the October *Journal*, for his contribution to the Discussion which followed the above paper — p. 661, col. 3, last paragraph:

Walter Bach (*Berndt-Bach, Inc.*): I would like to make a brief statement on printing and slippage. About 25 years ago, C. N. Batsel of RCA presented a paper entitled "A Non-Slip Sound Printer" (*Jour. SMPE, 23:* 100–107, Aug. 1934). Then, about 20 years ago, E. W. Kellogg of RCA presented a paper on "Reduction of Loop-Length Variations in Non-Slip Printers" (*Jour. SMPE, 30:* 136–149, Feb. 1938). In New York we spent a number of years in further developing these non-slip printers for optical soundtracks on 16mm film. These prints completely eliminated slippage—even though the negative is shrunk and the positive isn't. We were able to print up to 10,000 cycles on 16mm soundtracks running 36 ft/min, with no degradation on the prints whatsoever. This would be equivalent to printing and reproducing 25,000 cycles on 35mm film running at 90 ft/min.

A New Additive Color System for Motion-Picture Photography

By LIONEL H. WHEELER

An additive color system has been designed for use in motion-picture production. The system is also applicable to color TV and Armed Forces instrumentation photography. The problems of an operational additive color system are outlined and the solution to these problems is related to the Colorvision camera, printing and projection equipment. The technique of making subtractive prints from an additive negative is described.

THE DEVELOPMENT of the Colorvision System since 1950 falls quite broadly into three major phases. The first was concerned with the anticipation, at long range, of the development of color television and the concept that an additive motion-picture color system would present great advantages and would be compatible with the requirements of color television.

The second phase involved the development of an optical design for the "taking system" and the building of an experimental unit with a Standard Mitchell Camera which served to prove that the approach to the problem was sound. A modified version of the prototype was then developed which adapted the optical system to the N. C. Mitchell Camera. Also included in this second phase was the design of an experimental superimposing device with which subtractive print tests could be made. The first experiments with additive projection might also be included in this second phase. Lawrence F. Brunswick in a paper at the Society's Convention in Los Angeles in 1954 covered the development up to that time.*

Presented on April 24, 1958, at the Society's Convention in Los Angeles by Lionel H. Wheeler, Colorvision, Inc., 6061 W. Third St., Los Angeles 36.
(Received in revised form September 3, 1958.)

The period since 1954 may be regarded as the third phase, during which time the effort has been devoted to: first, the concept of a complete operational system which would meet the requirements of the professional producer; and second, the creation of operational equipment to cover these requirements. The Colorvision Camera Unit has undergone quite extensive modification during this third phase but basically the principles remain the same. A dichroic beam-splitting optical unit is used in conjunction with an unmodified N. C. Mitchell Camera. Mitchell accessories such as matte-box, viewfinder, etc., are also used (Fig. 1). Bayonet-mounted 35mm, 50mm, 75mm and 125mm objective lenses are provided with each unit and may be interchanged at will. Red, green and blue color separations are recorded within the area of a full aperture frame, each image being approximately 40% larger in area than a 16mm image (Fig. 2). Fast panchromatic negative is used and processed in the usual way. Basic exposure level is 200 ft-c for Eastman Tri-X Panchromatic Negative Film, Type 5233 and 400 ft-c for the new Eastman Plus X Panchromatic Negative Film, Type 4231 at Colorvision Stop 2. Depth of field at this aperture approximates that normally achieved at $f/4.5$.

Four Colorvision Camera Units for use with N. C. Mitchell Cameras are operational at this time, and an optical unit has also been aligned with an Acme Process Camera for animation, titling, etc.

Although basically designed for the producer of motion-pictures for television, Colorvision has also built operational equipment for the high-quality recording of color television. A beam-splitting optical unit has been integrated with an Acme Rapid Pulldown TV recording camera for this purpose. With the generous cooperation of the National Broadcasting Co., this method of recording has been proved to be entirely practical. It is obvious that video-tape recording presents great advantages in the field of the "hot kine," but Colorvision still offers, as far as can be ascertained, the only demonstrated method of color TV recording from which satisfying subtractive prints can be made for normal screening.

NBC has also generously cooperated in the practical and successful demonstration of additive projection for color television. Without modification to the three vidicon film camera, but with the replacement of the normal lens by the Colorvision lens, additive projection provides color in which very little degradation of the original subject occurs.

* Lawrence F. Brunswick, "Separation process for additive color motion-picture photography on black-and-white film," *Jour. SMPTE, 64:* 126–128, March 1955.

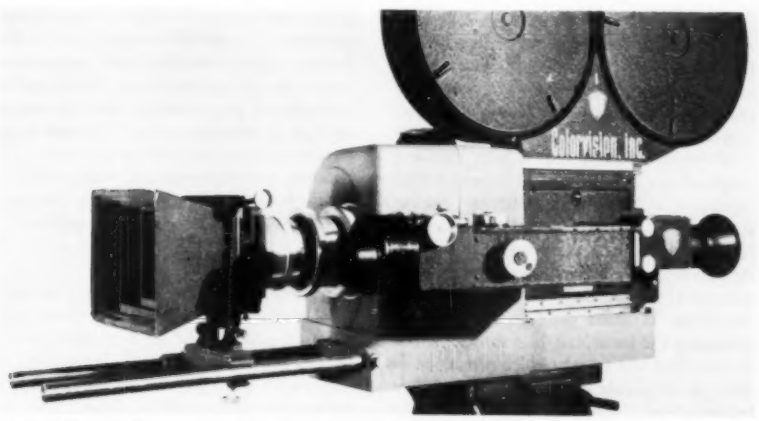


Fig. 1. Mitchell Camera used for Colorvision, including accessories such as matte box and viewfinder.

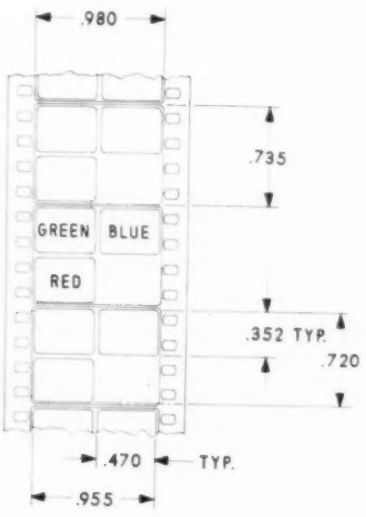


Fig. 2. Comparison of area and image size. Area of each Colorvision image is 0.1654 sq in.; 16mm camera aperture is 0.1205 sq in.

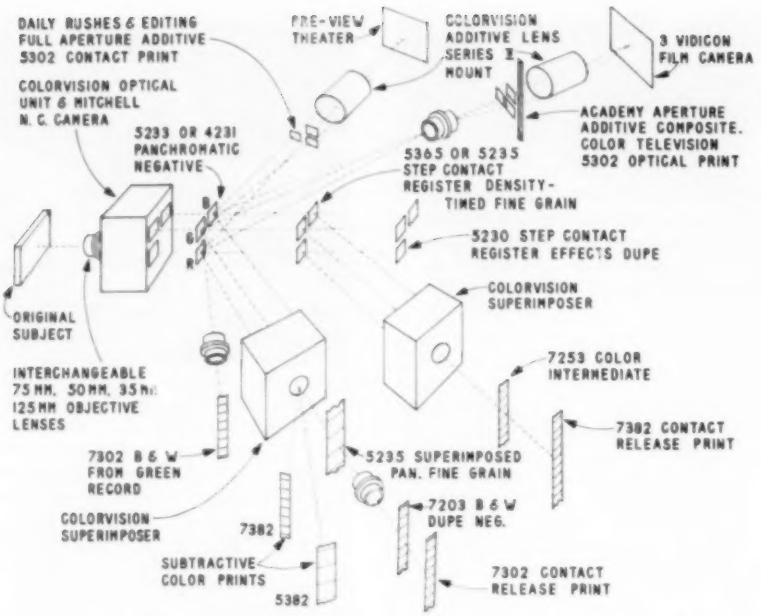


Fig. 3. Diagram of commercially available facilities and procedures. Original subject shown at left.

Presentation of this paper at the 1958 Convention of the Society coincided with the virtual completion of the operational nucleus of equipment of all kinds necessary to service production companies. Figure 3 illustrates the commercially available facilities and procedures from the original separation negative through additive, subtractive, and black-and-white prints.

Entirely successful demonstrations have recently been made before military groups.

Potential Photographic Fields

Colorvision has been designed to provide the producer of motion pictures for television with a color system which will greatly reduce his costs and still make available to him the various color print facilities to which he is accustomed. In addition to the usual variety of color prints, he may also view his dailies additively in color and later take advantage of the low cost and high color fidelity offered by additive projection when his program is telecast in color.

The Colorvision System may also be applied to the various photographic fields in which the Armed Forces are interested.

The Navy, for example, has a problem if it is desired to photograph and screen color at sea. 35mm black-and-white processing is available on most of the larger ships but it is considered impractical to install color processing equipment. Normally it is impossible to view color until the negative can be flown to some land-based laboratory. The use of an additive system would provide almost immediate viewing in color and could be followed at a later date by the distribution of color prints.

The Army has a problem in the instruction of short-term personnel in the techniques of scene-to-scene color timing. A color system in which this problem is greatly simplified would facilitate the production of large quantities of 16mm color prints.

High-speed camera instrumentation of tests of ballistic missiles and rocket sled performance involves an enormous proportion of wastage of color negative. An additive system would reduce the waste to the level of black-and-white, subtractive color prints being made only from selected sections of negative where action of specific interest occurs.

Operational Problems of an Additive System

In order for an additive system to approach any of these photographic fields successfully, it must meet a great number of operational requirements.

The optical design of the "taking system" must be such that a fully exposed negative can be obtained at a commercial light-level. This beam-splitting taking system must have no spatial or time parallax and should, therefore, expose the red, green and blue records at the same instant of time and through a single objective lens. It must provide a means of changing the focal length of this objective lens so that the usual choice of angles of view is available, including the ability to use a lens of comparatively wide angle if desired.

Definition, in proportion to the negative area, must compare favorably with conventional cameras.

It is important also that the exposure balance between the color separations be controlled so that the red, green and blue records are of equal density and contrast and that this balance be standardized from one unit to another.

The camera that is used in conjunction with this optical system should preferably be one in general use, one that does not require a nonstandard movement — such as a three perforation pulldown, for example. Operation of the camera and optical unit in combination must be conventional and place no additional burdens on the operator or his assistant.

Before this combination of optical system and camera can be used in the field, it is necessary to define and provide for further operational considerations, the most important of which may be register. Here the problem is to place three color separation images of precisely the same size in a certain fixed relationship to each other and in a certain alignment with the perforations, then to be able to repeat this interrelationship from one optical unit to another. A quick method of checking this standard register must also be established.

Very slight differences may occur from one Mitchell Camera to another and a means of measuring these differences must be found so that they may be accommodated. The shrinkage of the film base itself would affect register; but fortunately the general use of acetate enables us to calculate, from the most pessimistic data published, and prove with practical tests that the errors due to shrinkage cannot be discerned.

The optical unit must be stable enough to permit quite extensive temperature changes without register being affected and also be stable enough to withstand a certain degree of rough handling. If a camera unit should be dropped and shooting continued with a possibility of misregister, means must be available for providing a reregistered dupe negative.

As a corollary to the problem of the taking system, a method of additive projection is needed, one which is simple and inexpensive, provides adjustments for initial register and does not require the use of the taking system, or modification of standard projectors. It must be stable enough in operation to withstand temperature changes and to perform consistently without constant readjustment. The solution of these problems, the goal of Colorvision, has been accomplished.

Subtractive Printing

The use of additive projection has certain limitations, therefore the usual subtractive prints must be available to the user of an additive system. It may be of interest to describe the procedure when subtractive prints are required.

In order to explain the somewhat simplified timing method, it is necessary to re-

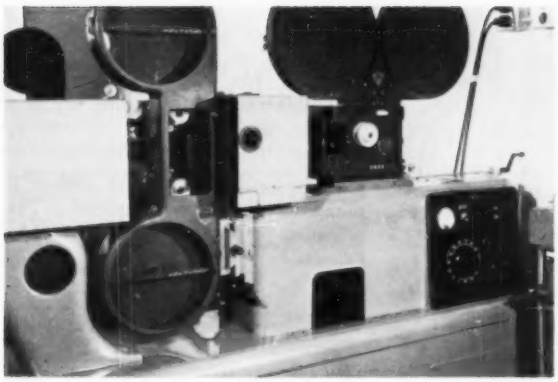


Fig. 4. Acme Optical Step Printer with Colorvision Superimposer installed.

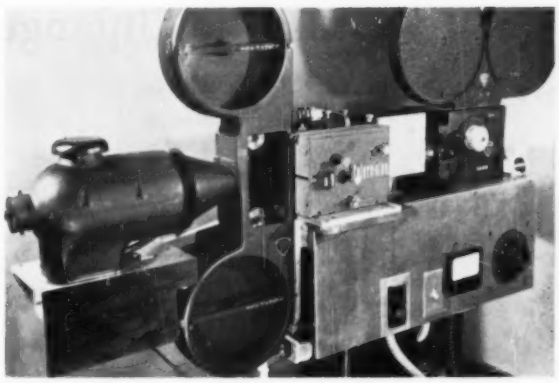


Fig. 5. Colorvision Printer.

fer to the color balance of the Colorvision Camera Unit. It is possible to control and standardize the exposure level of each of the three separations so that the negative density is almost precisely the same on each record. Indirectly, this also controls, to some extent, the relative contrast of each image.

This condition of color balance is tested by photographing a gray scale at 3200 K. The negative densities may then be plotted against the reflection densities of the gray scale to ensure that underexposure or over-exposure, or variations in development, do not change the relationship between the three separations. After testing a great number of batches of Eastman Tri-X Panchromatic Negative Film, Type 5233, the variations in color sensitivity from one batch to another were found to be so small that it was deemed unnecessary to rebalance the camera unit to accommodate a change in negative batch.

This overall stability of spectral sensitivity has made it possible to time for density only, from scene to scene. There are certain exceptions; for example, if exteriors were photographed without a color-temperature conversion filter, it would undoubtedly be necessary to correct the negative unbalance by the use of either additive lamphouse or filter pack timing techniques during the printing operation. If it is assumed that no such departure from normal photographic techniques has taken place, the problem is reduced to the assessment of density changes from scene to scene. To do this, and therefore save wastage of color positive, we have installed a Depue Reduction Printer slightly modified to print only the green record from the 35mm negative onto Eastman Fine Grain Release Positive Film, Type 7302 at a reduction ratio of 0.84 using a Z47 Ektar copying lens. With this equipment it is possible to establish the scene-to-scene density timing by the use of typical black-and-white techniques.

After the density changes from scene to scene are established, these light changes may be transferred to the 16mm and 35mm color printers. These are simplified versions of the Acme Optical Step Printer on which Colorvision's 16mm and 35mm Superimposers have been installed (Fig. 4). The Superimposer is merely a dichroic beam-splitter in reverse which makes it possible to register and print all three records at the same time.

Some experiments have been made with flashing techniques to give a certain amount of control of contrast in the yellow, cyan and magenta layers during the printing operation. As a part of this experiment, a neutral partial reflecting mirror was mounted at 45° between the superimposer and the camera. A light box with suitable diffusion and 47B + 2B Wratten filters was mounted at right angles to the normal optical axis so that the mirror reflected the light and enabled a controlled amount of fog density to build up in the blue sensitive layer while simultaneously printing the action on all three records.

When large numbers of color prints are required it is not practical, for various reasons, to make these prints from the original negative. Another superimposing printer has been installed to make a 16mm color internegative from which contact prints can be made (Fig. 5). The procedure is to make, from the original negative, a density-timed step-contact register fine grain. From this, through the superimposing printer, the internegative can be printed on one light.

Experiments with various contrasts on the fine grain are planned and trial runs on the alternative internegative stocks which are available will be made.

Fades and dissolves have been included in the various types of prints. These are duplicate negatives inserted into the original negative as is typical in black-and-white. They were made by Film Effects of Hollywood on step-contact register printers from Eastman Fine Grain Duplicating Positive Film, Type 5365. They were printed on Eastman Background-X Panchromatic Negative Film, Type 5230 to avoid color shift from original negative to dupe, due to the base stain which Type 5203 carries.

Other printing techniques are available and we are following further avenues in experimenting to obtain the best quality for the various types of prints which are required.

The Electrostatic Uniangular Microphone

By HARRY F. OLSON
and JOHN PRESTON

The electrostatic uniangular microphone consists of an electrostatic transducer combined with an acoustical network to provide a uniform response with respect to frequency and a uniangular directivity pattern. The microphone exhibits a high order of directivity. The polar directional pattern is independent of the frequency.

CONVENTIONAL SOUND PICKUP in television and motion pictures presents difficult problems because the microphone must be kept out of the picture. The immediate consequence of this method of operation is a relatively large sound pickup distance. The ratio of the signal to the ambient noise output of the microphone is an inverse function of the distance between microphone and source of sound and a direct function of the directivity of the microphone. The ambient noise in both television and sound motion pictures is being increased continually because of the ever greater activity of complex productions. The net result is a need for a more directional microphone which will improve the ratio of the signal-to-noise output of the microphone.

Because of the complexity of productions in both television and motion pictures, the sound pickup system must exhibit a high order of mobility in order to follow the action. A lightweight microphone which can be used on a small and lightweight boom of either the carriage or hand supported type is a necessity.

A study of the requirements revealed that an electrostatic transducer with uniangular directivity would satisfy the requirements; consequently what has been termed the electrostatic uniangular microphone was developed.

Presented on April 22, 1958, at the Society's Convention in Los Angeles by M. Rettinger for the authors Harry F. Olson and John Preston, RCA Laboratories, Acoustical and Electromechanical Research Laboratory, Princeton, N.J. (This paper was received on June 9, 1958.)

Description

The electrostatic uniangular microphone consists of an electrostatic transducer combined with an acoustical network to provide uniform response with respect to frequency and a uniangular directivity which is independent of frequency.

The electrostatic transducer is a generating system in which the electromotive force is developed by the motion between two electrostatically charged plates. The open circuit voltage* developed by the electrostatic transducer due to a relative displacement of the plates with respect to each other is given by

$$e = \frac{e_0}{a} x_D \qquad (1)$$

where e = open circuit voltage, in v,
e_0 = polarizing voltage, in v,
a = spacing between the plates, in cm, and
x_D = amplitude of the motion of the movable plates, in cm.

Equation (1) shows that there is a constant relationship between the amplitude of the diaphragm and the open circuit voltage output. In a microphone, in which the response is independent of the frequency, there must be a constant relationship between the actuating sound pressure and the open circuit voltage output. Since the electrostatic uniangular microphone is a gradient microphone,† the actuating sound pressure is proportional to the frequency. The actuating pressure may be expressed as follows:

$$p_D = K_1 p\omega \qquad (2)$$

where p_D = actuating pressure, in dynes/sq cm.,
K_1 = constant of the vibrating system,
p = sound pressure in free space, in dynes/sq cm,
$\omega = 2\pi f$, and
f = frequency, in cycles/sec.

The amplitude of the diaphragm is given by

$$x_D = \frac{p_D A}{j\omega z_M} \qquad (3)$$

where x_D = amplitude of the diaphragm, in cm.
A = area of the diaphragm, in sq cm
z_M = mechanical impedance of the vibrating system, in mechanical ohms.

Combining Eqs. (2) and (3), the amplitude of the diaphragm is given by

$$x_D = \frac{K_1 p\omega A}{j\omega z_M} = \frac{K_1 pA}{jz_M} \qquad (4)$$

Equation (4) shows that the amplitude will be independent of the frequency if the mechanical impedance z_M is a mechanical resistance. In other words, the vibrating system must be "resistance controlled."

A schematic sectional view and the acoustical network of the electrostatic uniangular microphone are shown in Fig. 1. In order to provide uniform response and directivity with respect to frequency, the acoustical resistance r_{A1} in branch 1 of the acoustical network must be the controlling acoustical im-

*Harry F. Olson, *Dynamical Analogies*, D. Van Nostrand Co., Princeton, N. J., 1958.

†Harry F. Olson, *Acoustical Engineering*, D. Van Nostrand Co., Princeton, N. J., 1957.

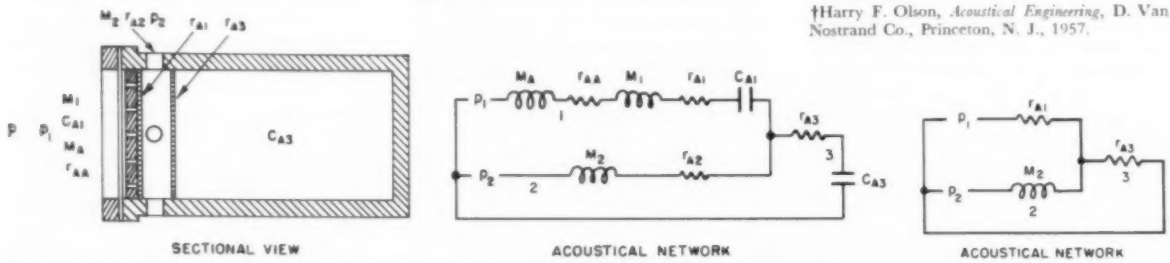


Fig. 1. Sectional view and acoustical network of the electrostatic uniangular microphone. In the acoustical network: p_1 = sound pressure at the diaphragm. p_2 = sound pressure at the apertures. M_1 and C_{A1} = inertance and acoustical capacitance of the diaphragm. M_A and r_{AA} = inertance and acoustical resistance of the air load upon the diaphragm. r_{A1} = acoustical resistance behind the diaphragm. M_2 and r_{A2} = inertance and acoustical resistance of the apertures. r_{A3} = acoustical resistance of the termination. C_{A3} = acoustical capacitance of the volume of air in the case. p = sound pressure in free space.

Fig. 2. Simplified acoustical network of Fig. 1.

pedance. For the same reasons, the acoustical resistance r_{A3}, in branch 3, must be the controlling acoustical resistance. The acoustical resistance r_{A2} of the apertures is small compared to the acoustical reactance of the inertance M_2 of the apertures. Under these conditions the acoustical network can be drawn as shown in Fig. 2.

The volume current in branch 1 due to the pressure, p_1, is given by

$$\dot{X}_{11} = \frac{p_1(r_{A2} + j\omega M_2)}{r_{A1}r_{A3} + j\omega M_2 r_{A1} + j\omega M_2 r_{A3}} \tag{5}$$

where $\dot{X}_{11}$ = volume current, in cu cm/sec,
p_1 = actuating pressure at the diaphragm of the microphone, in dynes/sq cm,
r_{A1} = acoustical resistance behind the diaphragm, in acoustical ohms,
r_{A2} = acoustical resistance of the termination, in acoustical ohms, and
M_2 = inertance of the apertures, in grams per (cm)^4.

The volume current in branch 1 due to the pressure, p_2, is given by

$$X_{12} = \frac{p_2 r_{A3}}{r_{A1}r_{A3} + j\omega M_2 r_{A1} + j\omega M_2 r_{A3}} \tag{6}$$

where $\dot{X}_{12}$ = volume current, in cu cm/sec, and
p_2 = actuating pressure at the apertures of the microphone, in dynes/sq cm.

Let the reference point of zero phase be at p_1, then the expression for p_1 may be written

$$p_1 = p_{01}\epsilon^{j\omega t} \tag{7}$$

where p_{01} = amplitude of p_1, in dynes/sq cm, and
t = time, in sec.

The expression for p_2 may be written

$$p_2 = p_{02}\epsilon^{j\left(\omega t + \frac{2d\pi}{\lambda}\cos\Theta\right)} \tag{8}$$

where p_{02} = amplitude of p_2, in dynes/sq cm,
d = effective acoustic path from the diaphragm to the aperture, in cm,
λ = wavelength, in cm, and
Θ = angle between the axis of the microphone and the direction of the incident sound wave.

The resultant volume current in branch 1 which is the volume current of the diaphragm is given by

$$\dot{X}_D = \dot{X}_{11} - \dot{X}_{12} \tag{9}$$

The volume displacement in branch 1 is given by

$$X_D = X_{11} - X_{12} \tag{10}$$

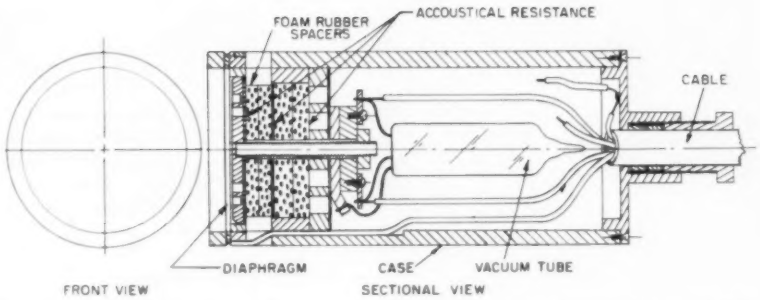


Fig. 3. Front and sectional views showing the elements of the electrostatic uniangular microphone.

where $X_D = \frac{\dot{X}_D}{\omega}$

$X_{11} = \frac{\dot{X}_{11}}{\omega}$

$X_{12} = \frac{\dot{X}_{12}}{\omega}$

If the pressures p_{01} and p_{02} are equal to the free field pressure p and the distance d is small compared to the wavelength and the values of r_{A1}, r_{A3} and M_2 are selected to provide a cardioid pattern, the volume displacement of the diaphragm can be expressed as

$$X_D = K_3 p(0.5 + 0.5\cos\Theta) \tag{11}$$

where K_3 = constant of the acoustical and electrical system, and
p = sound pressure in free space, in dynes/sq cm.

The amplitude of the diaphragm is given by

$$x_D = \frac{X_D}{A} \tag{12}$$

where x_D = amplitude of the diaphragm, in cm,
X_D = volume displacement of the diaphragm, in cu cm, and
A = area of the diaphragm, in sq cm.

Combining Eqs. (1), (11) and (12), the open circuit voltage developed by the microphone is given by

$$e = K_4 e_0 p\,(0.5 + 0.5\cos\Theta) \tag{13}$$

where K_4 = sensitivity constant of the acoustical and electrical system.

The directivity pattern as given by Eq. (13) is a cardioid.

In the development of this microphone it was found that the directivity could be improved by the proper location of the apertures along the cylinder. The reason for this state of affairs is that the diffraction phase effects are a function of the angle of the incident sound. It is beyond the scope of this paper to outline the effects of the location of the apertures upon the directivity. The response of the microphone as a function of the azimuth of incident with the directivity maximized by employing phase effects due to diffraction is given by

$$e = K_5 e_0 p\left(0.4 + 0.6\cos\Theta\cos\frac{\Theta}{3}\right) \tag{14}$$

where K_5 = sensitivity constant of the acoustical and electrical systems.

An examination of Eq. (14) shows that the directivity is greater than that of a cardioid. For example, at 90° the response is down 9 db from that of 0° as compared to 6 db for the cardioid pattern.

Front and sectional views of the microphone are shown in Fig. 3. The acoustical resistances are in the form of filter paper. The spacing of the filter paper and other parts is maintained by means of foam rubber. The acoustical resistance of the foam rubber is small compared to the filter paper and, therefore, does not play any major part in the operation of the vibrating system. Never-

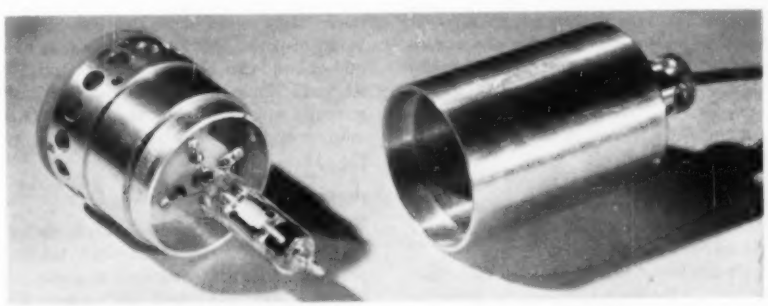


Fig. 4. The electrostatic uniangular microphone with the case opened.

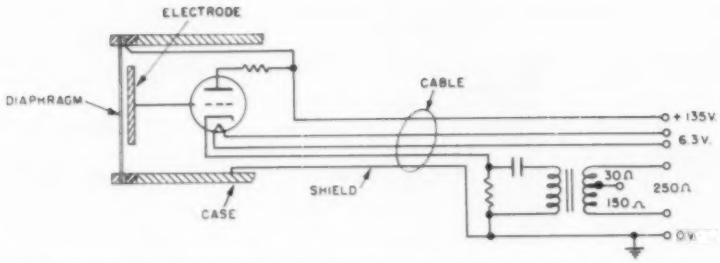


Fig. 5. Vacuum tube circuit of the electrostatic uniangular microphone.

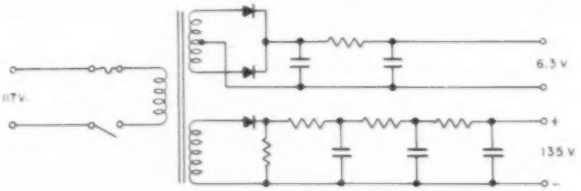


Fig. 7. Circuit diagram of the power supply.

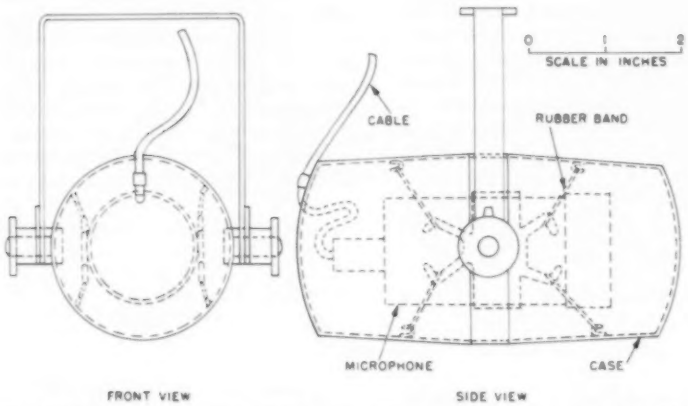


Fig. 8. Schematic of the protective screen with the microphone mounted inside the screen case.

Fig. 6. The power supply for the uniangular electrostatic microphone.

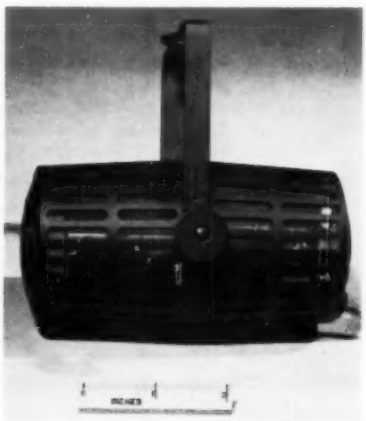


Fig. 9. The protective case for the uniangular electrostatic microphone.

theless, the acoustical resistance of the foam rubber is sufficiently high so that the resonances of the cavity between the boundaries of the two acoustical resistances are eliminated.

The microphone (Fig. 4) has a diameter of $1\frac{3}{8}$ in., length of 3 in. and weight of 3 oz.

The vacuum tube is mounted in the microphone case behind the terminating acoustical resistance and the rear boundary of the case. The vacuum tube circuit (Fig. 5) is of the cathode follower type. The output impedance is approximately 700 ohms. A matching transformer is provided at the end of the line at the power supply so that impedances of 250, 150 and 50 ohms can be obtained.

A power supply (Fig. 6) of direct current for the heater and plate supply from 115 v has been developed with circuitry as shown in Fig. 7.

A protective screen developed for use indoors is shown schematically, with the microphone mounted on the inside, in Fig. 8. The total weight of the microphone and the protective screen is 5 oz. The protective screen provides sufficient reduction in wind response of the type encountered in the motion of the microphone through the air on a boom. The protective screen case is shown in Fig. 9.

For use outdoors, and to reduce wind response of the microphone to a tolerable level, the screen shown schematically in Fig. 10 was developed. The total weight of the microphone and the relatively large wind screen is only 8 oz. Wind response tests have shown that the microphone can be operated in winds of moderate force without any deleterious response effects due to the wind. The outdoor-type wind screen is shown in Fig. 11.

Performance Characteristics

The response frequency characteristics of the electrostatic uniangular microphone for the incident sound at angles of 0°, 45°, 90°, 135° and 180° where 0° corresponds to the axis of the microphone are shown in Fig. 12. A consideration of these characteristics shows that the response characteristics in the front hemisphere are uniform with respect to frequency. The response at 90° is more than 9 db below that at 0°. The response characteristic in the rear hemisphere shows that the microphone exhibits a high order of discrimination to sounds arriving from the rear direction. The average polar directivity pattern is shown in Fig. 13. A visual inspection of the polar characteristics shows that the directivity is greater than that of a cardioid characteristic. The response of the angular microphone to random sounds is approximately $\frac{1}{4}$ that of nondirectional microphones as compared to $\frac{1}{3}$ for a microphone with a cardioid directional characteristic.

Summary

An electrostatic unidirectional microphone termed the electrostatic uniangular microphone has been developed with the following characteristics: a directional pattern given by $(0.4 + 0.6 \cos\Theta \cos\frac{\Theta}{3})$, where Θ = angle between the axis of the microphone and the direction

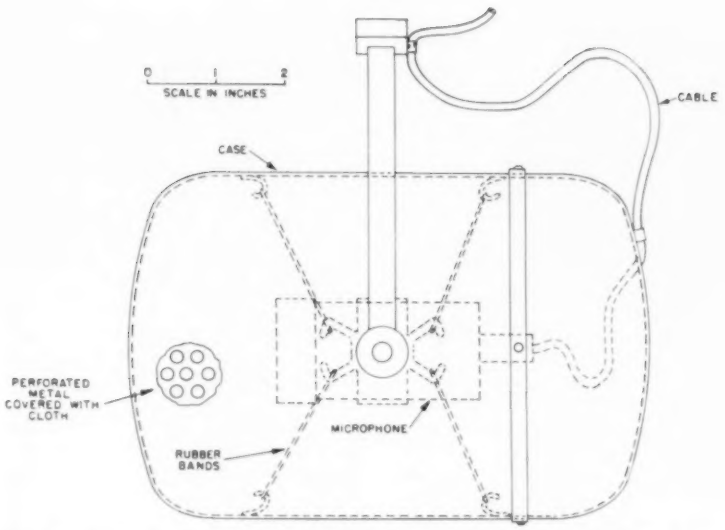


Fig. 10. Schematic of the wind screen with microphone mounted inside the screen case.

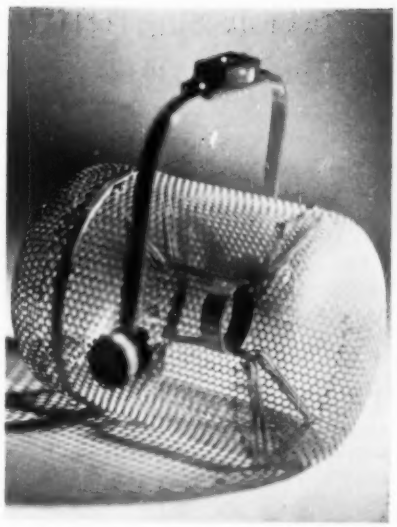


Fig. 11. The wind screen for the electrostatic uniangular microphone.

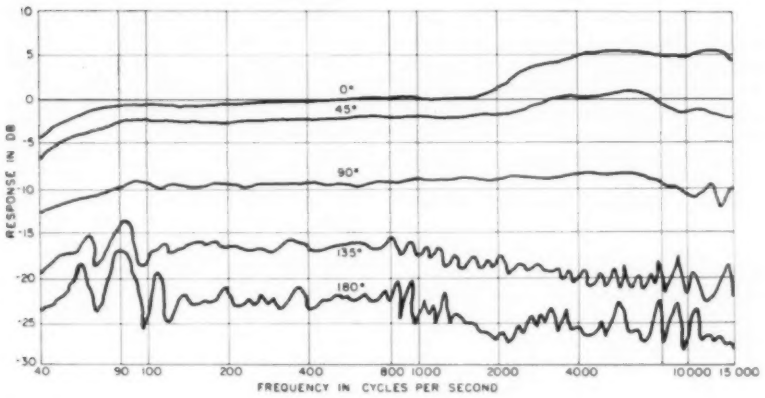


Fig. 12. The response frequency characteristics of the electrostatic uniangular microphone for the incident sound at angles of 0°, 45°, 90°, 135° and 180°. 0° corresponds to the cylindrical axis of the microphone.

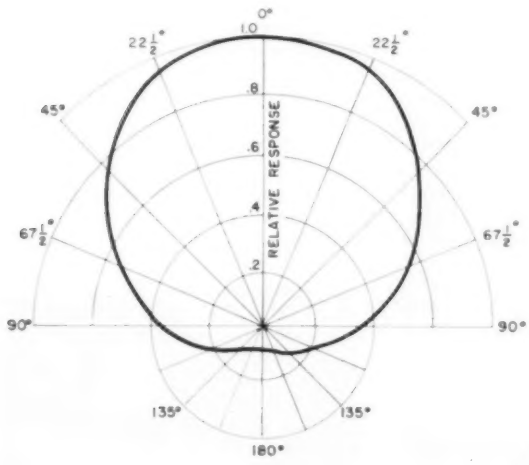


Fig. 13. The average polar directional pattern of the electrostatic uniangular microphone.

of the incident sound; a directional efficiency of $\frac{1}{4}$ as contrasted to $\frac{1}{3}$ for the cardioid pattern; an open circuit output of 0.8 mv/dyne/sq cm for a generator of 250 ohms, as contrasted to $\frac{1}{3}$ of this sensitivity for the most sensitive existing microphone; a cylindrical case $1\frac{3}{8}$ in. in diameter and 3 in. in length; a weight of 3 oz; an advanced type of electronic circuit; a specially developed type of power supply; and a lightweight wind screen for operation of the microphone outdoors.

Discussion

H. M. Tremaine (*Air Force Lookout Mountain Lab.*): Would you please state again the front-to-back ratio?

Mr. Rettinger (*who read the paper*): The microphone is more directional than the MI-10001, our unidirectional microphone. The response at 90 degrees for the unidirectional microphone is down 6 db, while for the electrostatic unit it is down 10 db.

Loren Ryder (*Ryder Sound Service*): Does this microphone have the same characteristic vertically that it has horizontally? Unfortunately, most directional microphones do not have the same characteristics vertically.

Mr. Rettinger: Yes, it is symmetrical in its directional response.

George Lewin (*Army Pictorial Center*): Would you say whether there is a problem with microphonics—in moving this "mike" around?

Mr. Rettinger: We have had little difficulty with microphonics normally generated by boom action, because the unit is so well shock absorbently mounted as not to permit the infiltration of undesirable boom vibrations. As is the case, however, with all microphones containing a vacuum tube, it is possible also with this unit that its tube may become noisy, and generate "microphonics."

A Portable Sprocket-Type Magnetic Tape or Film Recording System

By G. R. CRANE
and E. W. TEMPLIN

Three professional magnetic recording systems have been designed, employing sprocket-hole ¼-in. tape or 16mm or 17½mm films, to meet the operating and quality requirements of the motion-picture industry. One of two small carrying cases contains a two-position mixer, including preamplifiers, recording amplifier and the 115-v a-c system power supply. The recorder includes a bias oscillator and monitor amplifier, both transistorized. The recorder operates synchronously from an a-c line or from power derived from the camera motor.

IT HAS BEEN approximately eight years since Westrex introduced its first portable system for magnetic recording on sprocket-hole film. Except for certain packaging revisions and variations, especially in multichannel applications, the performance of this early system has stood the test of time and the components are still in general use under broadly diversified operating conditions and in widely spread geographical locations.

In designing the new portable system, factors of shape and arrangement, performance features and operating facilities have been established on the basis of experience with the earlier system and with careful consideration of those factors which should be improved or extended. Recent advances in magnetic recording were taken into account; and more economical means of meeting the requirements were sought, to bring the system within reach of a new market of small and independent organizations in this country and abroad.

Basic overall considerations which have established the design requirements for this new system are: The system should provide a positive method of synchronization of sound and picture. The system should be as small and as light in weight as possible, while retaining the present, high-quality professional standards of performance. To achieve flexibility, the system should accommodate recording on 16mm film, 17½mm film operating at 45 ft/min, or ¼-in. PerfoTape (which is somewhat new and the extent of whose use, as yet undetermined). PerfoTape has standard 16mm perforations and is run at standard 16mm speed. It has the advantage of requiring a minimum of storage space not only because of the narrower width but also because it permits use of either 1.5-mil or 3-mil Mylar base. The equipment, including transmission circuits and motor drive, must operate primarily from a 115-v, single-phase, 50- or 60-cycle source, with provision for alternative operation from a 24-v battery.

With the aim of keeping the size and weight to a minimum, careful consideration was given, very early in the development, to the use of transistors which reduce space requirements not only because they are smaller than vacuum tubes but also because of less associated power requirements, particularly since heater power is not involved. It became evident that the bias oscillator could be completely transistorized with no sacrifice in performance and with the power dissipation reduced from 4¼ w for the vacuum-tube unit to 1¾ w for the transistorized unit. Similarly, for the monitor reproduce amplifier, wattage was reduced from 6½ w for the vacuum-tube device to ¾ w for the comparable transistorized unit. The elimination of vacuum tubes in these two units permitted a very significant saving of space in the recorder.

Although the use of transistors for the microphone preamplifiers and recording amplifiers at first seemed preferable, it was decided, after careful study, that miniature vacuum tubes should be retained. The primary reason was an unwillingness, even in this lightweight system, to make any compromise in signal-to-noise ratio and in distortion for the required wide range of input signal level. It was concluded that, at the present state of the art, transistor signal-to-noise ratio may be reduced quite closely to that of the best vacuum tubes, provided that the operation is over a limited range of the transistor transfer characteristic. From the operating standpoint, high-level mixer controls (preamplifiers ahead of the mixer potentiometers) were required in order to be completely free from noise introduced at this source. On this basis it was necessary to accommodate an input level, nominally −70 dbm, but ranging downward at least 50 db and upward an additional 30 db, for a total required linear operating range at the preamplifier input of approximately 80 db. It did not appear wise to accept the complexities of circuitry in which the mixing would take place simultaneously in more than one transistor stage.

To supply the complete transmission system, silicon semiconductor rectifiers were used for both the low-voltage and the high-voltage supply to achieve a significant reduction in space, as well as improvement in operating efficiency due to the inherent low forward resistance and high reverse resistance of these components.

Since, from the operating standpoint, mobility of the mixer is much more important than that of the recorder, it was decided that the system should be packaged in two units (Fig. 1). Both units are mounted in plastic-covered plywood cases.

The overall dimensions of the mixer are 16⅝ in. wide, 10 in. high and 5⅝ in. deep. Its total weight is 22 lb. The mixer is normally supplied with a suitcase-type handle and may be operated with the panel in the upright position, since the interconnection receptacles are on the rear. An optional bar-type handle may be provided, placed so as to support the mixer with the panel in an inclined position on a table surface (Fig. 2). An optional tripod and tripod mount are also available. The recorder, which includes the bias oscillator and monitor amplifier, is 19 1/16 in. wide, 13 9/16 in. high and 7⅞ in. deep and weighs approximately 35 lb.

Each unit is directly served by its own a-c power cable. Only one interconnecting cable is required between the mixer and recorder. This contains the 600-ohm high-level record line and the 24-v d-c supply from the mixer to the transmission circuitry within the recorder. The other cables to the mixer include the two microphone inputs, and the optional boom-monitor output.

Mixer

The mixer circuit is shown in simplified schematic form in Fig. 3. It contains provisions for two microphone inputs and all of the associated transmission circuitry through and including the recording amplifier output. The power

Fig. 1. Westrex RA-1592 Mixer and RA-1591 Recorder.

Presented on April 22, 1958, at the Society's Convention in Los Angeles by G. R. Crane and E. W. Templin (who read the paper), Westrex Corp., 6601 Romaine St., Hollywood 38.
(This paper was received on May 12, 1958.)

supply for the complete transmission system operating from a 115-v, single-phase a-c line is also included in this package.

Each microphone input contains a two-stage preamplifier utilizing a 12AY7 vacuum tube. This is followed by separate dialogue equalization and mixer controls for each microphone circuit. Dialogue equalization of 0, 8 or 12 db at 100 cycles/sec may be selected. Since the mixer inputs operate at a relatively high signal level, approximately 0.5 v, it is possible to use commerical composition potentiometers coupled between the plates of the preamplifiers and the grid of the common main amplifier, thus eliminating the need for interstage transformers and the more conventional high-quality mixer potentiometers. These standard potentiometers with the appropriate taper characteristic provide a continuously variable attenuation range of over 60 db, thus eliminating the need of any supplementary gain-control switches. For the nominal input level of −70 dbm the potentiometer is set to provide a range upwards of 20 db and a useful range downward of 40 db before tapering to complete cutoff.

The combined output of the two mixing potentiometers is fed into a three-stage recording amplifier, the last of which is a phase inverter push-pull stage.

Fig. 2. Westrex RA-1592-A Mixer ready for use in inclined position supported by bar handle.

The 600-ohm output to the recorder is capable of transmitting a signal 8 db above the nominal record level with not more than 1% distortion over the operating frequency range. A feedback circuit in the three-stage recording amplifier section provides the standard 6 db low-frequency pre-equalization characteristic associated with 16mm recording (the ISO-SMPTE 16mm characteristic) and a portion of the high-frequency equalization character-

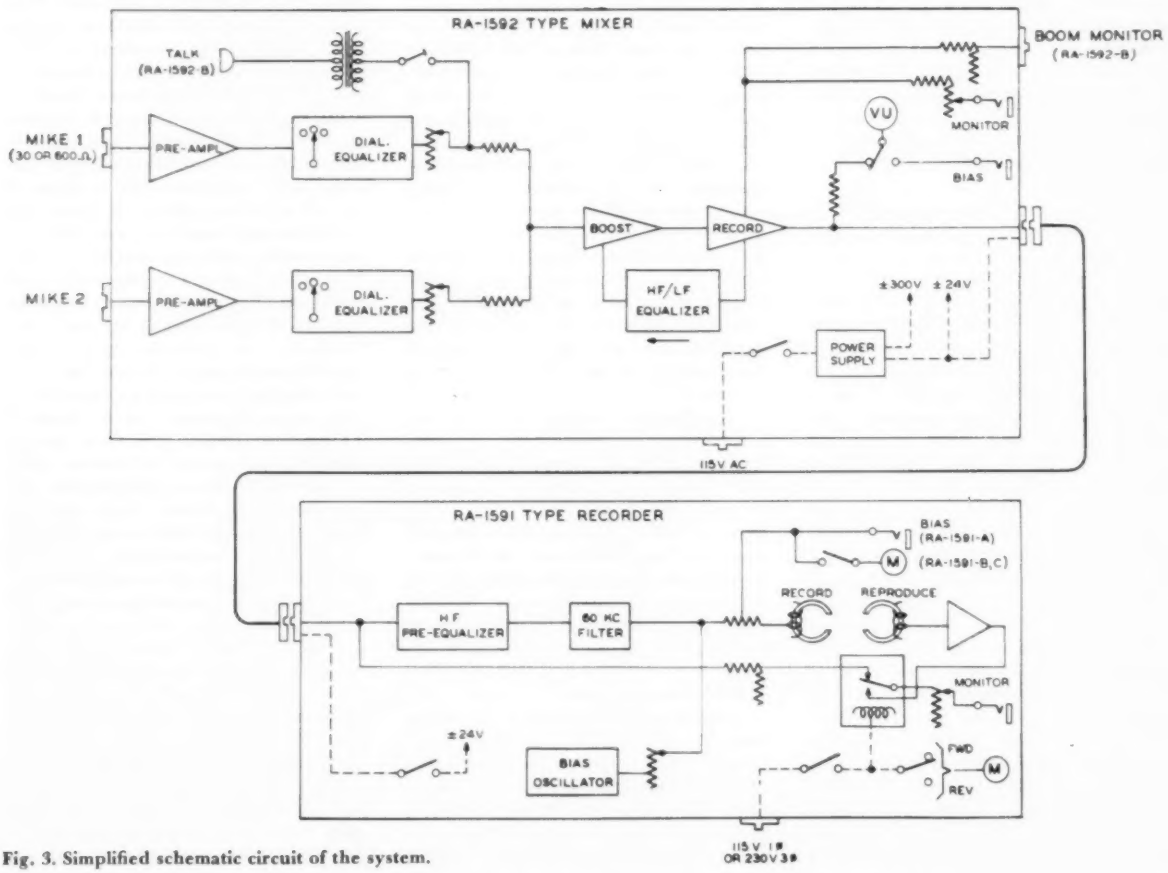


Fig. 3. Simplified schematic circuit of the system.

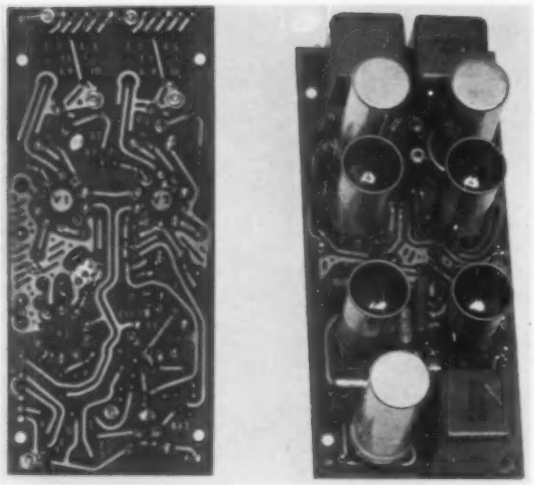


Fig. 4. Front and rear of etched circuit amplifier assembly.

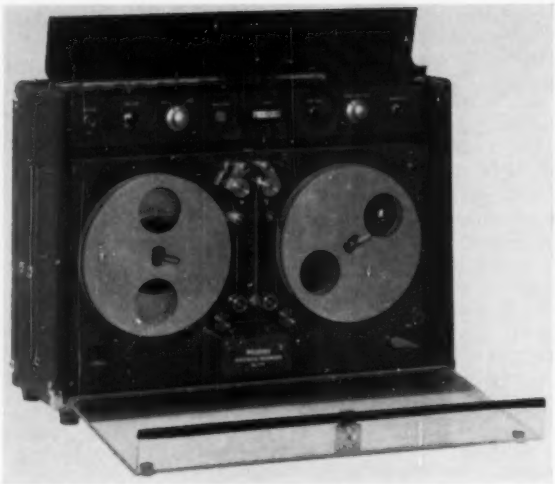


Fig. 5. Westrex RA-1591-B 16mm recorder.

istic amounting to approximately 5 db at 10 kc. The remaining portion of the high-frequency pre-equalization, to provide the standard 16mm recording characteristic, is located in the recorder in the series circuit feeding the record head. A direct-monitor output for the mixer operator at a nominal −4 dbm level is available for a 50-ohm high-quality dynamic headset.

The entire amplifier circuitry from the dual preamplifier input through the recording amplifier output, with the exception of the front panel controls, is assembled on one compact etched circuit board, the dimensions of which are 3½ in. by 8 in. Figure 4 shows a front and rear view of this etched circuit amplifier assembly.

Recognizing that the etched circuitry technique is still in the early stages of development, every effort has been made to retain maximum reliability and ruggedness, and it is believed that there has been no compromise in either respect in this application. It is recognized that in studio equipment electronic units must be capable of being repeatedly repaired or modified. The ability to withstand replacement of circuit elements, such as resistors and condensers, was achieved by the use of improved funnel-shaped eyelets in all "thru-holes" from top to bottom surfaces. These assure a positive soldered contact with the soldered area exposed for inspection.

A laminated glass epoxy board is used. This material, similar in electrical properties to silicone glass, has three times the bond strength to the conducting lamination, one-fifth the moisture absorption, and five times the flexural strength of XXXP phenol board.

A 2-oz copper lamination is applied to each side of the epoxy material and is gold-flashed after etching. It will be seen that the etched circuitry is on both the top and bottom surfaces of the etched board, but that all of the components have been placed on the top side. This permits the use of the dip-soldering process for all connections on the under side which in itself results in a significant cost saving. The circuitry has been laid out very carefully to provide a high degree of isolation between the two mixer inputs and between both of them and the common output circuits. In many cases grounded etched-circuit areas have been included to improve this isolation and to provide shielding from the 24-v and the 300-v power circuits. The printed board amplifier assembly is flexibly mounted in a vertical plane and is completely accessible for inspection or voltage measurement with the front panel in the open position. This front control panel is hinged along the bottom and secured by two Camloc fasteners so that it may be readily opened for access to the mixer interior. Four additional Camloc fasteners permit removal of the complete mixer chassis assembly from the wooden enclosure.

The VU meter is set for 0-db deflection for program material at the 3% distortion level on the magnetic medium. A switch permits changing the sensitivity to 0-db deflection for a sine wave signal at this 3% distortion level, for test recording purposes. A circuit interlock disables the monitor when the VI switch is in the test position so that the latter may not be left inadvertently in the incorrect position during a recording without drawing the attention of the mixer operator.

There are two versions of the mixer unit, the simpler one being intended primarily for the PerfoTape System, and the other version intended for the 16mm and 17½mm systems. The latter contains the additional facilities of talkback-slating microphone and boom monitor output. The former may be readily converted to the latter type by the addition of a small kit of parts.

Recorder

The recorder is mounted in a small wooden carrying case which has the advantages of good insulation against acoustic noise, light weight and adequate ruggedness. Figure 5 shows a 16mm recorder in readiness for operation. The film compartment is enclosed by a clear plastic door hinged at the bottom, which provides for quiet operation and complete visibility. The control panel is mounted above this door and contains all the controls which are considered essential for large-studio operation. The control panel is also enclosed by a hinged door when the equipment is not in use. The film path is symmetrical and contains two film sprockets, two filter rollers, two impedance drums and two idler rollers which guide the film to and from the film reels. Each of the two filter rollers has an associated target plate. These movable plates overlap, but when their adjacent points are in alignment it is an indication that the correct length of film has been threaded between the two sprockets. The record and monitor heads are located in the film path between the two impedance drums. Each magnetic head is provided with a small shield which can be adjusted for minimum hum pickup, thus eliminating the need for a shielded compartment about the heads.

The film path between the two sprockets contains a mechanical filter which attenuates variations from constant film speed at the translation points. The inertia for the filter is supplied by the two impedance drums and their associated flywheels. Damping is obtained by an air dashpot attached to one filter arm. Part of the compliance is furnished by a spring connected between the two

arms. With only this compliance, the natural period of the system is about 30 sec, and this has been reduced to about 1½ sec by attaching two opposing springs of proper rate to one filter arm. One of these springs is anchored to the chassis frame. The other spring is attached to a cord which is wound around a capstan. This provides means for adjusting the spring tension to center the filter arms to their mean position under operating conditions. The uniformity of film motion is well within the requirement for the intended application of the recorder. Under normal operating conditions with normal film, the flutter performance is of the order of 0.1% rms with no value of flutter at any single rate exceeding approximately 0.07%.

The film sprockets are driven by a small flexibly mounted motor and two worms and worm gears. Four types of motor operation are available. These are provided by either a 115-v, single-phase or a 230-v, three-phase motor operating from a 50- or 60-cycle line. Due to the small amount of power required, the latter motor can be connected to the three-phase windings of a multiduty camera motor and operated by the camera motor in synchronism with it. The recorders equipped to use ¼-in. PerfoTape or 16mm film operate at 36 ft/min and accommodate a maximum of 600 ft of 3-mil base with a running time of approximately 16½ min. The recorder equipped to use 17½mm film operates at 45 ft/min and accommodates a maximum of 500 ft of 5-mil base with a running time of approximately 11 min. As an alternate choice 3-mil base may be used, in which case the running time is approximately 13 min. Each of the recorders may be operated in the reverse direction at normal film speed for rewind purposes. A footage counter is equipped with a manual reset and counts footage in either direction of film travel.

Irrespective of the direction of film travel, take-up tension is applied to the appropriate reel spindle and drag is applied to the other spindle, the selection being made automatically by the direction of rotation of the machine drive. Take-up tension is provided by slippage of a driven flat endless cotton belt on the polished surface of a stainless-steel pulley. The pulley is coupled to the reel spindle through a helical-spring overrunning clutch. Depending on the direction of film travel, the clutch on the take-up spindle locks and the one on the drag spindle slips freely. Take-up tension is adjusted by setting the belt tension with adjustable spring loading.

Drag tension is provided by a similar pulley fixed to each reel spindle and slipping on a fixed, spring-loaded section of the same belt material. Depending on the direction of film travel, the pulley on the drag spindle is rotated in a direction which pulls the fixed end of its belt, producing drag tension. The pulley on the take-up spindle is rotated in a direction which pulls the spring-loaded end of its belt and a relatively low drag opposes the rotation. Drag tension is likewise adjustable by altering the spring tension.

The operating controls, with the exception of the motor direction switch, are mounted on the front of the control panel. There are a motor switch, a selector switch for setting the circuits for recording and reproducing, a signal lamp which lights when the circuits are set for recording, a bias meter and a bias adjustment control, a pushbutton switch which connects the bias meter to read the 24 v supplied from the mixer equipment, a monitor level control, and a jack for connecting the monitor headphones.

Two relays are provided for remote operation of the recorder, particularly when driving the three-phase motor from the multiduty camera motor. One is operated as a function of the record-reproduce selector switch and the motor direction switch. In the record and forward positions of the switches, the relay allows normal recording operation. With the switches in either the reproduce or reverse positions, the relay prevents recording. The second relay is operated from the motor circuit so that when the motor circuit is open, direct monitoring is obtained and when the motor circuit is operating, film monitor is provided.

In the recorder, the transistorized bias oscillator, the transistorized monitor amplifier and all of the electronic circuitry, including the input connecting receptacles and the front panel controls, are mounted on or within a shallow tray which may be pulled out readily from the front or removed for maintenance purposes. Two short cables within the recorder connect this electronic assembly tray to the record and reproduce heads and to the motor circuits. In addition to the two transistorized units, the recorder circuitry also includes the second portion of the high-frequency recording pre-equalization, the bias suppression filter, direct and film monitor circuits and record-reproduce switching.

The 60-kc bias oscillator employs a 2N270 transistor in an L-C oscillator circuit with a thermistor in the feedback circuit for level stability. This stage is transformer-coupled to a push-pull output stage utilizing two 2N301 transistors. The output circuit contains filtering consisting of a 60-kc single-tuned output transformer, and a 120-kc series anti-resonant circuit. In addition, the recording head, which is separated from the oscillator by a series bias adjusting rheostat, is shunted by a condenser to provide 60-kc antiresonance. The harmonics in the resultant bias current are at least 60 db below the fundamental which assures freedom from d-c magnetization noise and distortion.

In the PerfoTape version of the recorder, no bias meter is provided. Bias current may be measured by a short patch cord connecting between the recorder and the VU meter in the mixer. In the 16mm and 17½mm versions the bias meter is included on the recorder and may be used also to measure the 24-v supply to the recorder by operation of a pushbutton switch.

The transistorized monitor amplifier is a 5-stage, transformerless unit. The input is capacity-coupled from the 500-mh reproduce head and the output capacity-coupled to the 600-ohm headset monitor output. Two feedback paths around the first two and the fourth and fifth stages, respectively, provide the equalization. Either the NAB or the ISO-SMPTE reproduce characteristics are obtainable by internal strapping. A volume control is provided between the second and third stages. The amplifier has less than 1% distortion at 0-dbm output. It has more than sufficient gain to produce this output level from a 90-mil fully modulated magnetic track.

A 600-ohm monitoring headset output is provided, normally a Trimm type S-35 headset being supplied for this application. When the recording machine is not running, the direct monitor is connected to the output jack which permits communication from the mixer to the recordist. With the motor system energized, the monitoring is automatically transferred from direct to film and under these latter conditions the direct and film monitor can be compared by a momentary pushbutton which returns the monitor circuit to the direct line.

Conclusion

As indicated in the early portion of this paper, there has been no significant compromise in any respect with regard to performance in these new systems, although a considerable reduction in weight and size has been effected by the various expedients described. The distortion of the transmission system is well below 1% over the entire audio-frequency range for operating levels up to 8 db above that corresponding to 3% distortion on the magnetic medium. For a normal −70 dbm input to the mixer, a 52- to 55-db signal-to-noise ratio is obtained at the output of the recording circuitry as determined and limited by the inherent noise of the low-noise-level input tube. The 55-db signal-to-noise ratio of the monitoring amplifier permits the recorder to be used also for reproduction during the subsequent dubbing process — a feature which can be very important to the small independent studio.

Discussion

George E. Ison (Army Signal Corps, Fort Sam Houston, Texas): You mentioned the possibility of using Mylar base tape for your machine. Did your company make a test for print-thru with the Mylar base film?

Mr. Templin: No.

Chester E. Beachell (National Film Board of Canada): I understand that part of your record equalization was obtained with feedback in your recording amplifier. Can you compensate for this in your monitor output so that your monitor actually has a flat response?

Mr. Templin: Yes, the pre-equalization which is in the recording circuit is completely compensated for in the reproducing amplifier so that the overall response is flat.

Mr. Beachell: Is this true for the direct monitor?

Mr. Templin: In the direct monitor that is also done to some extent; however, the headsets favored by the studios cut off at around 5,000 to 6,000 cycles so we do not have to compensate for all of the high pre-equalization. At the mixer, where direct monitor only is present, we retain the low-frequency pre-equalization in the monitor circuit as a compensation for the inherent low-frequency droop in the headset response. In the recorder, where direct and film monitor are both available and film monitor must have a flat overall characteristic, compensation is provided in the direct circuit for the low-frequency pre-equalization.

A Film-Processing Machine of Flexible Characteristics

By IRWIN A. MOON
and F. ALTON EVEREST

A combination 16/35mm, black-and-white and color processing machine has been constructed at Moody Institute of Science. Unconventional features include individual torque motor drive on each shaft, the lack of full-shaft elevators, novel recirculation and constant-tension systems, automatic pile-up and break controls and the use of plastic materials throughout.

EQUIPMENT specialization is common in the modern film-processing laboratory. Machines may be designated for processing only black-and-white or only color film. These may accommodate 16mm only or 35mm only or other film. In some laboratories a different machine is used for positive than for negative film. Obviously, some of this specialization is the result of capacity requirements or operating considerations, but to a considerable extent much is the result of the inflexibility of conventional drive systems.

Film-processing machines are commonly driven by a single motor driving a multiplicity of shafts, each through an adjustable friction clutch. By careful adjustment and readjustment of all clutches on a given machine, a condition can usually be attained in which the tension on the film and the film motion are satisfactory and differential stretching or shrinking of the film are adequately compensated for. When one type of film is running at or near a single standard speed the initial adjustment of a clutch-driven machine is a formidable task. For a versatile machine to handle different film widths, types of film or processes, such a friction clutch drive is quite impractical.

The unusual film-processing requirements of the Moody Institute of Science brought the extreme inflexibility of conventional drive systems into sharp focus. To overcome this inflexibility, a film processing machine was devised with many novel and unusual features which may be of interest to the industry. Specifically, this machine presents features affecting the drive system, the solution-level control, construction materials, constant terminal film tension, etc.

Presented on April 23, 1958, at the Society's Convention at Los Angeles by Irwin A. Moon and F. Alton Everest (who read the paper), Moody Institute of Science, 11428 Santa Monica Blvd., Los Angeles 25.
(This paper was received on March 31, 1958.)

Machine Description

The drybox end of a processing machine incorporating rather remarkable features of flexibility is shown in Fig. 1. The control and loading facilities are shown in Fig. 2. A separate electric motor is used for each shaft and this motor drives a single upper roller on that shaft. The array of drive motors is shown in Fig. 3 as viewed from the developer end of the machine. Figure 4 illustrates the ease with which individual film racks can be raised and placed in an overhead suspension for repair, inspection or maintenance procedures. Combination tapered rollers* are utilized so that either 16mm or 35mm film may be accommodated.

Because of the individual rack drive system, tanks may be readily skipped by suitable threading and by disconnection of the drive motors of unused sections. In this way different types of both black-and-white and color film may be processed in the same machine by having separate tanks where necessary, but sharing compatible sections such as fixing,

* Fonda Corp., 1040 N. McCadden Pl., Hollywood.

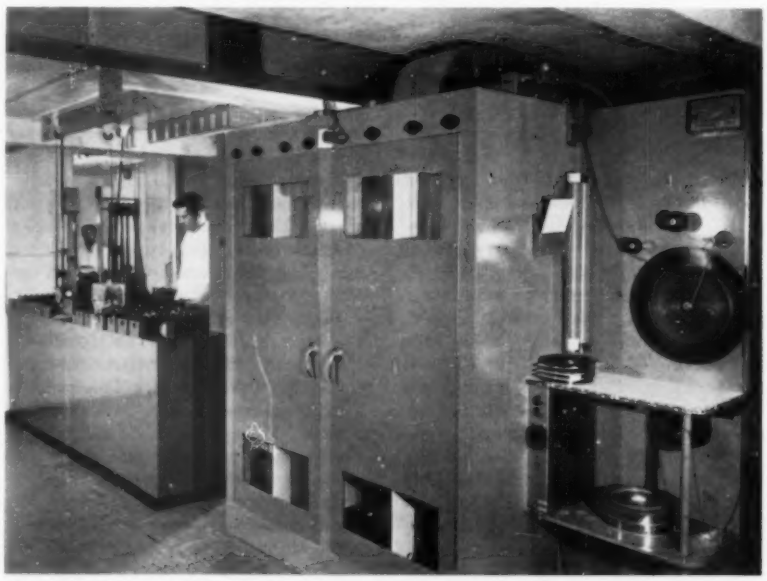


Fig. 1. Drybox end of the Moody processing machine designed for unusual operational flexibility.

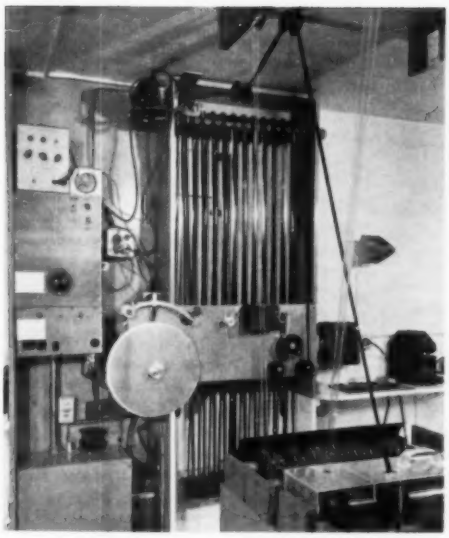


Fig. 2. Loading end of the Moody processing machine. Because the shafts of this machine are individually driven by torque motors, the position of the loading accumulator can be made in any convenient orientation to the direction of film flow.

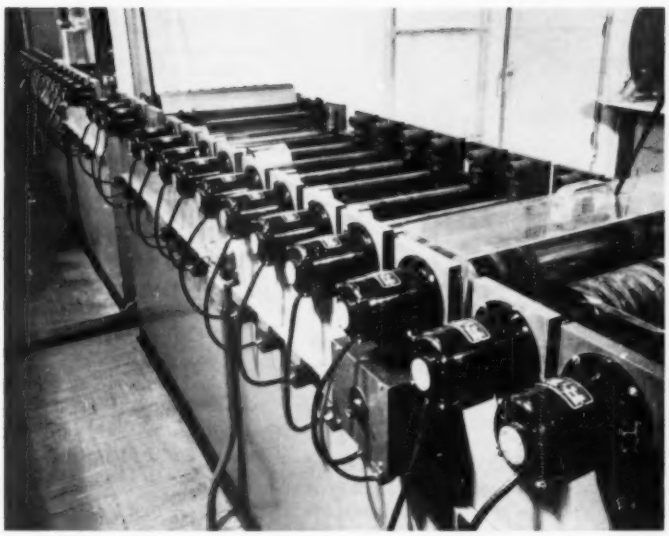


Fig. 3. The array of torque motors driving individual shafts as viewed from the developer end of the machine.

washing, stabilizing, drying and waxing. With this system it is also easy to lead the film path off to one side from the main direction of flow to go through a side tank added to the main machine.

Table I lists the various processing steps used in this laboratory and indicates the sections used with the different processes and types of film. The nominal processing speeds attained in each case, varying from 30 to 100 ft/min, further emphasize the versatility of the individual motor drive system. Table I illustrates the diversity of processing tasks employed in this particular instance and in no way exhausts the full range of possibilities.

Torque Motor Drive System

The ideal electric motor for driving individual shafts of a film processing machine would produce adequate torque at shaft speed (50–100 rpm), would not burn up with rotor blocked over a period of time, and would have a no-load speed only slightly greater than normal operating speed (say 200 rpm). To our knowledge, such a motor is not available, but the commercially available "torque" motor meets two of the three requirements and an auxiliary device can meet the third. This torque motor is a variable-speed induction motor having a rotating field produced by the stator acting on the rotor in such a way that high torque is produced at speeds far below synchronous speed, and even under blocked rotor conditions.

Table I. Processing Routines and Machine Sections.

Processing Steps	Eastman Color Release Positive (16mm and 35mm)	Eastman Color Internegative (16mm)	B&W Positive Release and Sound Negative (16mm)	B&W Picture Negative (16mm)
Dark				
B&W developer			X(D-16)	X(D-76)
Spray rinse			X	X
Pre-bath/spray rinse	X	X		
Color developer	X	(½ section)		
Spray rinse	X	X		
First fixing bath	X	X	X	X
Water wash	X	X	X	X
Light				
Bleach	X	X		
Water wash	X	X		
Soundtrack dev.	X			
Water wash	X			
Second fixing bath	X	X		
Water wash	X	X	X	X
Stabilizing bath	X	X	X	X
Drying	X	X	X	X
Waxing	X		X (Sound Neg. *not* waxed)	
Nominal Processing Speed, ft/min.	46	46	Pos., 100 Snd. neg., 30	45

Fig. 4. The individual racks may readily be lifted from the tanks for inspection, repair or maintenance.

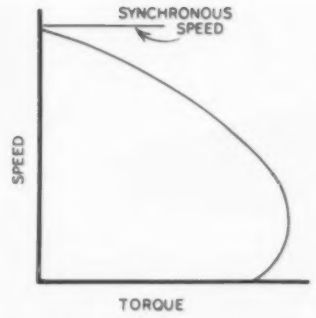


Fig. 5. The characteristic shape of the speed-torque curve of the commercially available "torque" motor.

The rotating field can be produced by a polyphase power source and winding or by such methods as the permanent split-phase-capacitor system on single-phase power. In the machine to be described, the Bodine Type NCI-13 fractional horsepower single-phase motor was utilized having a speed-torque characteristic such as that shown in Fig. 5.

Using a separate electric drive motor on each shaft offers a number of advantages:

(1) Silent operation compared to mechanical drives.

(2) Freedom to skip sections at will by simply "jump" threading and disconnecting unused motors.

(3) By slight voltage adjustments, compensations can be made for changing over from one size film to another.

(4) After a machine has been standing, a temporary overvoltage will assist in overcoming static friction, and the set of the film.

(5) Individual racks can actually be lifted out of solution for inspection without stopping the machine.

There is one disadvantage: the great disparity between the shaft speed of the usual film-processing machine (50 to 100 rpm) and the no-load speed of presently available torque motors (see Fig. 5). If the film should break, the motors relieved of their load would tend to accelerate to the synchronous speed (1800 rpm in this case). This would unthread rollers and throw film and solution. This inherent disadvantage of the commercially available torque motor for this purpose can be minimized in the following ways:

1. By placement of a step-down gearing or belt-pulley arrangement between the motor and the shaft being driven.

2. By using specially designed motors having characteristics more adaptable to this function. The variation of the number of stator poles and rotor resistance could conceivably be used to alter the torque-speed characteristic to a more favorable shape.

3. By utilizing direct drive with conventional motors in conjunction with suitable control devices.

This last method offers practical advantages and such a control device will be described.

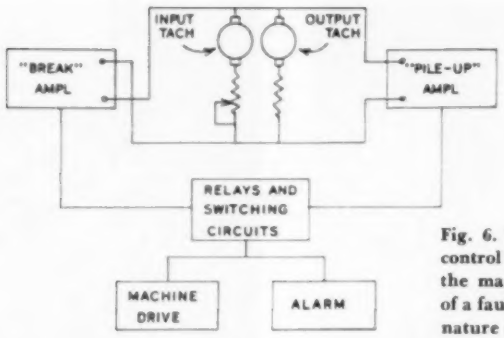


Fig. 6. The break/pile-up control circuit which stops the machine in the event of a fault and indicates the nature of the fault.

Film Break/Pile-up Control Device

In the event of a film break, all motors following the fault tend to accelerate and do damage. In the event of a film "jam" or "pile-up," all motors following the fault will tend to stop. The sooner such faults are detected the better the chance of correcting them and of saving the film in the machine.

A small tachometer generator† connected to the metering shaft acts as a speed-sensing element at the input to the machine. A similar one mounted on the last shaft acts as a sensing element at the output. These two generators are connected in parallel as shown in Fig. 6 in such a way that the positive terminal of one and the negative terminal of the other are connected together. The voltage generated by the input generator is proportional to the speed of the metering roller, and that of the output generator is proportional to the speed of the last shaft. With identical generators, the two voltages will be essentially equal in normal operation and a potential of approximately zero will be applied to the terminals of the amplifiers.

In the event of a film break, the output generator speeds up, applying a large voltage to the amplifiers of a polarity which causes actuation of the relays associated with the break amplifier. When a film pile-up occurs, the voltage of the input generator will prevail which is of a polarity to actuate the pile-up amplifier and associated relays. The machine is immediately stopped by the occurrence of either type of fault and an alarm is set off which indicates the nature of the fault.

As the machine is being started, the entire control circuit is deactivated so that normal starting transient conditions can be accommodated. By the use of a control device of this nature, the chief problem associated with the use of readily available torque motors is minimized.

† Servo-Tech d-c Generator Type SA-7408-1.

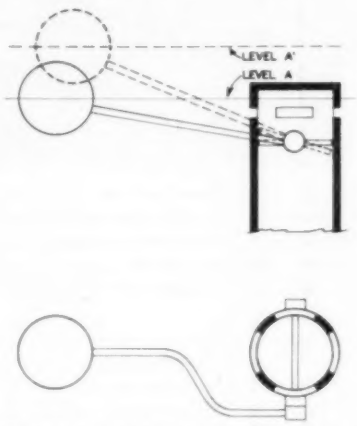


Fig. 7. Liquid-level control device of extreme simplicity which avoids aeration of solutions.

Recirculation System

In film-processing laboratories it is usually expedient to locate the replenishing and recirculating tanks on the floor below the processing machines proper. The machine tanks are supplied with fresh solution from the recirculating tank below by a pump, and the solution level in the processing machine is commonly maintained by a float-actuated switch and a solenoid-operated valve controlling the return flow. In the present recirculation system the level is maintained and the recirculation rate is controlled by cheaper but wholly effective means.

Figure 7 depicts the automatic solution-level control device. This is essentially a polyvinyl chloride (PVC) plastic standpipe with a capped upper end which incorporates a float-operated butterfly valve located below the apertures. Without the butterfly valve and float arrangement this pipe would act as a simple standpipe tending to maintain a liquid level at approximately the bottom of the apertures. However, in so doing, air would be sucked by vortex action through the apertures and bubbles would be introduced into the solution contributing to froth and foam formation, oxidation, and other detrimental factors.

By mounting the butterfly valve just

below the apertures and adjusting the float so that the normal level is maintained just above these apertures, air is not introduced and a continuous column of solution is maintained in the standpipe between the level of the processing tank and the level of the liquid in the recirculation tank below. The weight of this column of liquid would seal a needle valve shut so that a simple float system would lose control. With the butterfly valve, however, the column of solution pulls down on both sides of the valve, neutralizing its sealing tendency and making it possible for a simple float to exert sufficient control. When the recirculating pump is turned off, the solution level falls, closing the butterfly valve. In case the column of solution in the standpipe is accidentally drained out, the level in the processing tank can never drain lower than the apertures, thus eliminating the risk of the processing tank emptying into the recirculating tank and overflowing it.

The solution lifted by the recirculating pump enters the processing tank through the recirculation return shown in Fig. 8. This return, constructed of PVC plastic, incorporates an undersurface orifice, a control valve and a siphon break. The valve is a simple plug which can be made to cover the outflow apertures by the adjusting screw. The siphon-break hole prevents the processing tank from being drained down to the bottom of the outer pipe when the recirculating pump is stopped. With the siphon-break, the liquid level will fall only to the bottom of the apertures.

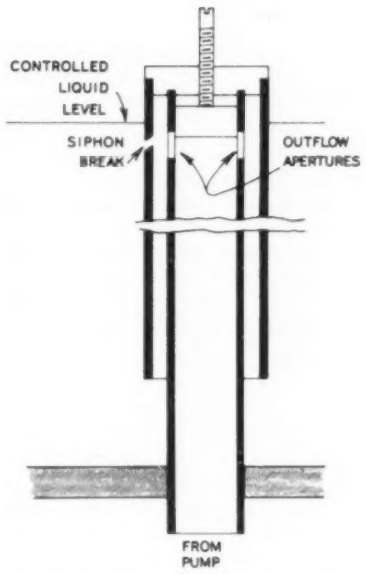


Fig. 8. Recirculation return with simple flow regulator.

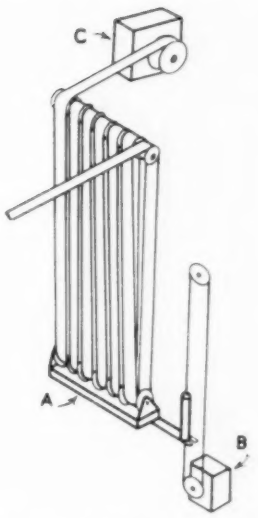


Fig. 9. System which maintains constant tension on the film going into or coming out of a film-processing machine.

Constant-Tension System

The smooth operation of film-processing machines is dependent upon uniform tension on the film throughout the machine. Two points tending to inject a varying film tension into the conventional machine are the loading and take-off points. In a machine utilizing the usual friction devices, for example, the film tension changes sevenfold as the film roll diameter changes from 2 in. to 14 in. This variability at loading and take-off ends affects machine operation adversely and subjects the film to "cinching," scratching and embossing hazards. The torque motor system here described yields constant film tension at these two crucial points, thus contributing to the stability of operation of the machine.

For loading a film-processing machine with unprocessed film or taking off the processed film at the other end, the film flow must be temporarily interrupted. To maintain continuous flow through the machine, time for the loading and unloading operation is obtained by a section equipped with a movable elevator. As the film is clamped during reloading, the elevator on the loading end rises as film flows from this section to the machine. The comparable elevator on the output end falls as it accumulates the film from the machine while rolls are removed.

The up-and-down motion of these elevators is used to provide control for maintaining constant film tension by the take-off system illustrated in Fig. 9. The elevator, A, is free to rise or fall and in so doing causes the voltage output of autotransformer B‡ to vary. As this autotransformer voltage is applied to the torque motor, C, on the take-up shaft, we see that the film tension is under the continuous control of the elevator position. The weight of elevator A makes it tend to fall, but in falling, the autotransformer shaft is rotated in such a way that greater voltage is applied to torque motor C. With these two opposing tendencies acting, a point of equilibrium will continually and automatically be sought where one offsets the other. In other words, the tension on the film is kept

‡The Variac, General Radio Co., 275 Massachusetts Ave., Cambridge 39, Mass.

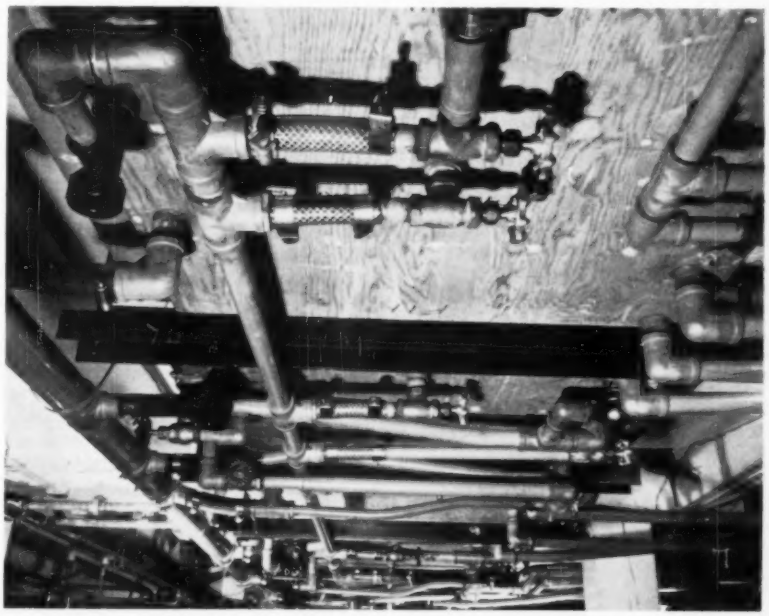


Fig. 10. View of the underside of the processing machine showing the plywood construction of the tank and the generous use of PVC plastic for the plumbing. The only vital use of stainless steel in this machine is in the film roller shafts.

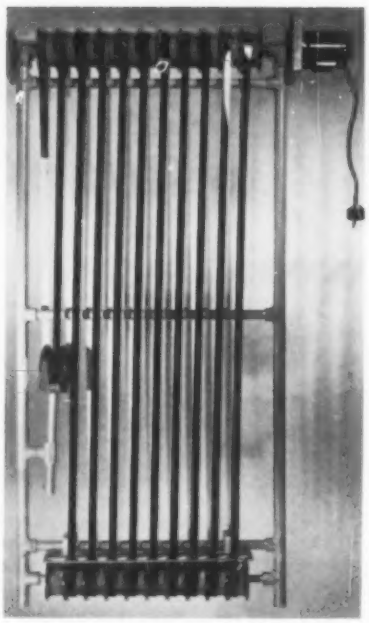


Fig. 11. Individual film rack showing the torque motor drive, the stationary lower shaft and single-strand elevator.

constant at a value determined by the weight of the elevator assembly. In a similar way, the film tension is maintained at a constant value on the loading end of the machine.

Construction

Plastic materials have been used in the construction of this machine in every instance possible. The tanks are made of 7-ply marine plywood ($\frac{3}{4}$-in. thickness) coated with polyester resin in which is imbedded Fiberglas cloth. Practically all plumbing is done with common PVC plastic tubing and fittings as shown by the view of the underside of the machine in Fig. 10. The ease of sawing this tubing to length and cementing fittings yields significant savings over stainless-steel plumbing. The plastic-coated plywood tanks are also much cheaper than stainless-steel tanks and several years' experience has revealed no basic problems.

The structural frameworks of the individual film racks are also made of PVC plastic. The only basic use of stainless steel in this machine is in the roller shafts. The shaft bearings are Teflon inserts designed for ease of replacement and the bakelite bearings of the Fonda tapered combination rollers have been replaced by Teflon bearings to reduce friction.

To minimize oxidation problems in the color developer solution, best practice dictates submerged upper rollers. The electric motor drives these submerged shafts by means of rubber belts which are rubber "O" rings of the type used for rubber seals.

A single rack removed from the tank is shown in Fig. 11. The use of PVC plastic in the construction of the rack is evident. The use of stationary lower shafts is a great deviation from standard practice. It was experimentally determined that a single-strand elevator in alternate racks was sufficient to provide the requisite stability which simplified the construction and maintenance problem very materially.

Acknowledgments

Invariably, projects at Moody Institute of Science are cooperative projects in practice and the enthusiastic and stimulating contributions of the following persons are gratefully recognized: Robert L. Miller, H. Balentine Reed, Lewis H. Humphrey, Estes C. Wright, Wil Rose, Willman Green and Donald Valentine.

Discussion

Richard Kise (*Radio Corp. of America*): What type of drying do you have—is it conventional or some other type?

Mr. Everest: It is conventional, that is, air drying.

Mr. Kise: What type of squeegeeing do you use?

Mr. Everest: We use the low-pressure air type of squeegee.

Wm. Gephart (*General Film Labs.*): Do you have any difficulty in following the 35mm film with 16mm or vice versa in the operation of the machine?

Mr. Everest: There is no problem when 16mm film follows 35mm film but the reverse situation must be closely watched. Careful tapering of the film at the splice is helpful.

A Color Timing Calculating Machine

By G. T. KEENE, A. J. SANT and J. D. CLIFFORD

A machine calculator based on the Wheatstone bridge principle is described. This machine will present information for additive or subtractive printing directly from the input data, which may be negative densities of a gray card in the scene or integrated full-frame negative densities. The input or output data appear simultaneously on the machine, thereby reducing the possibility of error. The timing error is ±0.03 log E for the first print relative to the standard print for the system in use.

Introduction

This paper covers the design, construction and use of a simple electrical device for calculating, from negative-density information, the printer balances for color motion pictures. The basis for this machine was presented by Keene in an earlier paper in which a slide-rule type calculator was described.[1] The present paper applies the filter equations previously found to an electrical analog computer designed and constructed by Sant and Clifford. This computer will directly provide filter and aperture settings for a reasonably balanced first print. The machine is so arranged that a switch from additive to subtractive printing can be quickly accomplished. Also, the input negative-density information may be either gray-card readings or full-frame integrated densities.

Theory of Negative-Density Timing

The theory of negative-density timing has been presented previously; only a brief review is given here for the benefit of those not immediately familiar with the methods involved.

The problems confronting a color timer result from a great number of factors. Among these are variations in the negative process, film-keeping effects both before and after exposure, use of improper filters or lighting, and errors in camera exposure. It is desirable that these factors be corrected to give a first print that is reasonably well balanced. Since many of these variations are not easily seen in the negative, a system of negative densitometry would be useful in obtaining a good first print.

Even if negative variations are recognized, the amount of printer correction that is required is difficult to establish, particularly in subtractive printing, because of the effects introduced by the unwanted absorptions of the filters and the number of filter faces. A mechanical timing method that takes into account all the characteristics of the printing system would be valuable in this situation.

In previous papers two methods have been presented for timing color motion pictures based on negative-density information. One is the full-frame integrated density technique described by Stott, Weller and Jackson[2] and the other the gray-card method presented by Keene.[1]

In the full-frame system the assumption is made that all scenes will have nearly the same integrated red, green and blue densities and that scenes differing in density from the average values must be corrected to some degree. The amount of correction required depends on the subject matter, the artistic effect desired, and the number and magnitude of variations in film exposure, handling and processing that are included. In practice, the correction level is chosen by trial-and-error timing of a representative group of scenes. A plot of the correct printer exposure vs. the negative densities gives the correction level as the slope of the best line through the data points.

The gray-card timing method requires that a neutral card be photographed when held in the key lighting of each scene. Only a few frames, correctly exposed, are required. In using this method it is assumed that the gray card should appear at the same color balance and density in all scenes. Accordingly, full correction is made, based on the densities of the gray card in the negative. All gray-card areas are printed to a preselected color balance and density, and most scenes are thereby brought to an acceptable balance on the first print.

Both methods are invalid when colored lights are used on the set or when deliberate distortions in balance are needed for special effects. In addition, the full-frame integrated method may be in error in scenes in which the subject or camera moves, or those in which there is a predominance of one color. A more detailed discussion of the theory and operation of both timing methods may be found in the two articles previously noted.

Machine Requirements

In the earlier paper,[1] it was pointed out that since the equations forming the basis for the slide-rule calculator are linear, it should be a relatively simple matter to construct a machine to perform the calculations automatically. The need for such a machine was soon evident, for the slide-rule operation requires considerable paper work and does have several steps in its operation at which errors can occur.

In subtractive printing, the machine must account for the unwanted effects of the printing filters. These include interface reflections and density in spectral regions other than the one desired. Figure 1 shows a spectral density curve for a typical magenta color-correction filter. The unwanted blue density region is found to the left of the primary green density peak and the filter has a minimum density of 0.05 at all wavelengths. Also, differences between the nominal filter densities and their effective density in the printer must be considered. In manual timing these compensations are learned by experience, but for a timing machine it is necessary to make allowance for each of the factors in the design equations. In additive printing the errors to be corrected are much more simple and include only a correction of the negative densitometry to true printing densities.

The requirements for the calculator can be specified as follows:

(1) Low cost — certainly under $500 if it is to have any general application.

(2) Ease of operation — must require no separate mathematical operations, tables or charts, and a minimum of pencil work.

(3) Speed — should double the speed of the slide-rule operation.

(4) Versatility — must convert easily for use with additive or subtractive printers, and handle either gray-card or full-frame information.

(5) Sensitivity — must respond to a density change of ±0.01.

(6) Reliability — must minimize possibility of error.

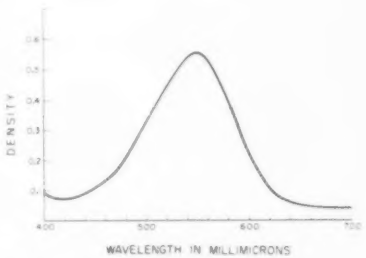


Fig. 1. Spectral density curve for a typical magenta color-correcting filter.

Presented on April 23, 1958, at the Society's Convention at Los Angeles by G. T. Keene, A. J. Sant and J. D. Clifford, Color Technology Div., Eastman Kodak Co., Rochester 4, N. Y. (This paper was received on May 18, 1958.)

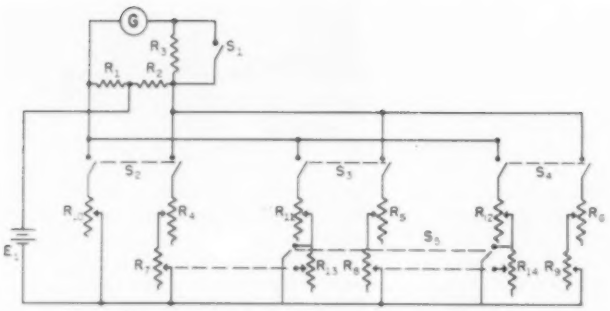


Fig. 2. Schematic diagram of the circuit of the computer.

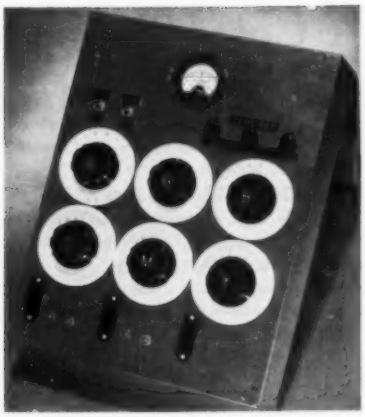


Fig. 3. General view of the computer.

Design

A detailed discussion of the calculations involved in the design is given in Appendix I. The following description will stress only the highlights of the machine's construction and operation.

Since a null-type operational setting often leads to speed and precision, the Wheatstone bridge principle was chosen for the calculator. A machine based on this principle is relatively independent of fluctuations in power supply and can operate from a low-voltage battery pack. The circuit (Fig. 2) is essentially three Wheatstone bridges, with a common galvanometer and power supply. In addition, two legs of the bridge are fixed resistors which, with the meter, establish the needed sensitivity and are common to all three circuits. All the remaining legs are precision potentiometers that furnish the setting, input and output adjustments for the machine. The unwanted absorptions of the cyan and magenta CC filters are compensated in subtractive printing through the two potentiometers labeled R_{13} and R_{14} which are linked by direct gearing to the cyan and magenta output potentiometers. Switch S-5 cuts out this compensation for additive printing.

The potentiometers are all accurate to at least 5% for resistance and 0.5% for linearity. These requirements increase the cost substantially, but are justified in order to obtain the accuracy and repeatability required in color timing.

Input-Output Dials

Figures 3 through 7 show the face of the computer in detail. For subtractive timing the input dials (Fig. 4) are divided with constant intervals per degree, but the intervals are different for the red, green and blue dials. The intervals are determined in each case by the primary absorption characteristics indicated in the filter equations (Eqs. 1, 2 and 3 of Appendix).

For the full-frame, integrated-density method, the correction level for the feature being timed must first be deter-

Fig. 4. Input dials for subtractive timing.

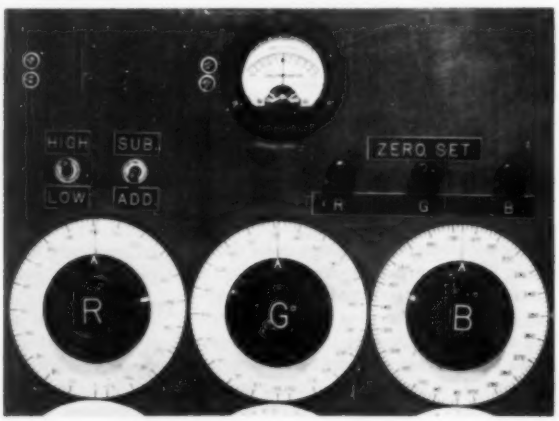


Fig. 5. Input dials for additive timing.

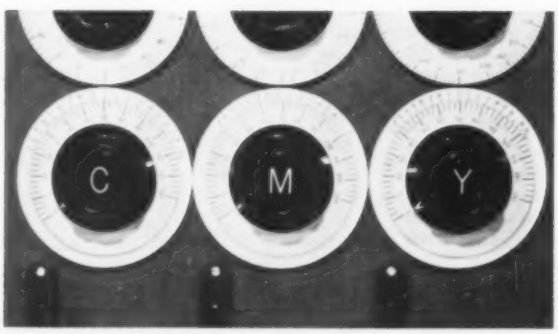


Fig. 6. Output dials for subtractive timing.

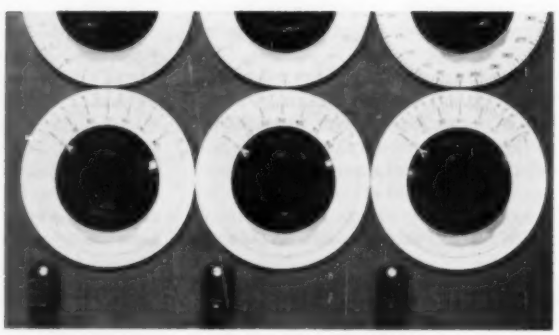


Fig. 7. Output dials for additive timing.

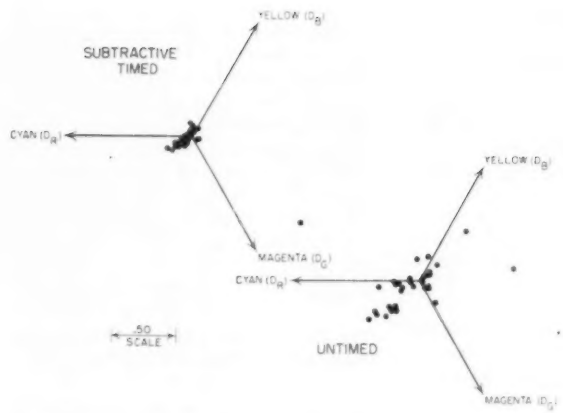


Fig. 8. Plots of color balance for subtractively timed and untimed prints.

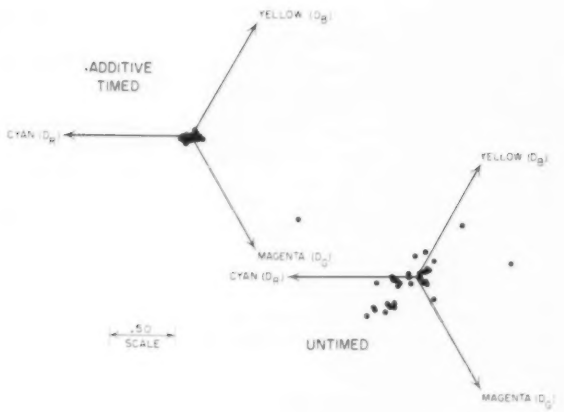


Fig. 9. Plots of color balance for additively timed and untimed prints.

mined and the proper input dials selected. These dials will have density increments that are less than those on the input dials used in the gray-card timing method by the amount of the correction-level factor. Thus, new input dials will be required in full-frame timing whenever a significant shift in correction level is needed. Such changes in correction level, however, will probably be fairly infrequent in any given laboratory, and a series of previously prepared dials should cover nearly all requirements.

The input scales for additive timing (Fig. 5) are also unequally divided owing to the printing density factors for the densitometry system. These factors account for the small differences between the way the negative is seen by the densitometer and by the Eastman Color Print Film. The red and green dials are identical, but the blue dial is scaled to put less resistance into the circuit than the straight density data would indicate.

The output dials for subtractive timing (Fig. 6) are all calibrated in equal and identical increments. A scale of printer apertures runs concentrically with each dial, and both aperture and filter scales are given equal log E increments; i.e., one division on the printer aperture scale (0.05 log E) equals a CC05 change on the filter scale. The output dials for additive printing (Fig. 7) are also equally divided and are calibrated in units of 0.02 log E to correspond to the increments of the beam attenuator in the additive printer. A colored dot at Aperture 10 serves as a reference mark for reading the output dials for additive printing.

Operation

The detailed operating instructions are given in Appendix II. When first applying the computer in a particular timing situation, the operator must adjust the machine for the setup on hand. The filter-correction switch is set according to the kind of printer, additive or subtractive. This switch controls the potentiometers that correct for the unwanted densities of the filters. For additive printing these potentiometers are switched out of the circuit. The correct input and output dials are selected and attached to the machine.

With the proper dials in place for full-frame timing, a scene with integrated densities near the average is chosen and printed to the desired balance using a setup near the mid-range of the color timing mechanism. The scene densities and printer balance are set on the input and output dials, respectively, and the galvanometer needle brought to zero by depressing each circuit switch in order and adjusting the setting knobs.

For gray-card timing, a scene with approximately average gray-card densities in the negative is selected and printed as for full-frame timing. The negative densities and correct printer balance are entered on the machine, and the galvanometer is zeroed for each circuit as just described.

The calculator is now ready to operate and will not require further adjustment unless a different emulsion number of print film is used or a process change occurs. Such changes are quickly and easily allowed for by a small change in the setting knob. The timing of all subsequent scenes is accomplished by entering the negative-density information on the input dials, restoring the meter to zero by turning the output dials, and reading out the indicated printer setups. For each scene for which a calculation is made the circuits must be balanced in the order red, green and blue.

Results

The following data are representative of results obtained using the gray-card timing system. The application in the full-frame timing system is identical once the correction level has been established.

To test the machine, 37 scenes were photographed on Eastman Color Negative Film, Type 5248. Included in the test were high-key and low-key scenes, interiors and exteriors, variations in exposure and color balance, and both fresh and aged film. At the start of each scene, a matte, gray card of approximately 20% reflectance was held for a few seconds in the key light. The card was large enough to allow densitometry of the processed negative image with a 3-mm aperture. Of course, the densities and color balance of the gray cards varied widely. A scene having average gray-card densities was balanced, and the printer information used to set up the calculator. The rest of the scenes were then timed in this same manner.

The success of the calculator was determined both by viewing the first print and by the uniformity of density readings from the printed gray-card patches. Figure 8 shows color-balance information from an untimed print and a subtractively timed print using gray-patch data. Color correction filters in density increments of 0.025 were used in a modified Bell & Howell Printer, Model D, running at 60 ft/min. The color-balance spread in the timed print is equivalent to a variation in printer exposure of ± 0.03 to 0.06 log E.

The dials on the computer were then changed for additive printing, and the same negative timed by this printing method. An experimental three-light printer was used with intensity controlled by carbon attenuators in 0.02 density increments. The color-balance plot for this test (Fig. 9) shows somewhat greater uniformity in the timed print than did the subtractively timed test.

Since data of this type show only color balance and do not indicate the accuracy of absolute density timing, a plot as shown in Fig. 10 is of value. Here, the variation in green density is shown for the untimed and the additively timed prints. Green density information

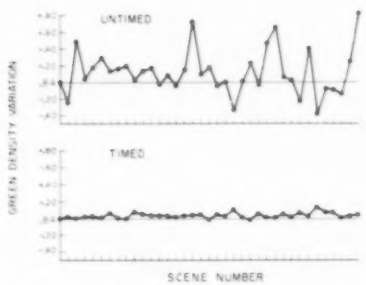


Fig. 10. Variation in green density of the gray cards on the untimed and additively timed prints.

only is shown, as the situation for the red and blue density data is very similar.

The precision of gray-card timing may be summarized:

	Log E Variation in Timing	
	Greatest	*Least*
Untimed	±0.42	±0.25
Subtractive, timed	±0.06	±0.03
Additive, timed	±0.04	±0.02

This order of error is probably sufficient to allow production of an acceptable print on the first printing. Subsequent small adjustments will sometimes be necessary for certain scenes or special effects, but these should be well under 0.05 log E.

Conclusion

The machine described will provide timing information so that any color negative may be printed to a close approximation of the final optimum balance on the first print. It is versatile, in that both full-frame and gray-card densities may be used to predict either additive or subtractive printing balances. The procedure for setting up the calculator in any particular situation is quite brief, simple and easily learned, requiring only determination of the proper dials and initial settings. Actual scene timing is nearly automatic with a minimum chance for error; the total calculating time per scene is about 20 sec. The chances for error are minimized by having the input and output data simultaneously visible on the machine. The probable cost for this unit including all parts and labor will be approximately $250.

There is the possibility of providing full automation for such a computer at considerably higher cost. Negative-density input data could be fed directly to the machine from the densitometer, and the predicted printing data could be sent to a tape punch or other device where a printer control record is made. Other possibilities for more automatic operation can be visualized, but all increase capital investment considerably, and some might limit the versatility of the more simple unit.

APPENDIX I

Design and Construction

Theory

The principles of construction and operation of the computer will be more easily understood if the problem it must solve is formulated purely from the operational standpoint. For a given combination of printer light source, exposure time, aperture and process, the exposures required to give a neutral gray of given visual density are fixed. Thus, if two uniform negative patches having different integral densities are to print to the same gray, the CC filter pack for each must be changed so that the final printing densities (filters + negative) are equal. In other words, differences in the filter packs must exactly compensate for differences in the integral densities of the negative patches.

For the slide rule, Keene[1] has given the following equations relating changes in filter pack to the measured integral densities of the color negative:

$$C = C_{BP} - 1.16\,\Delta D_R \quad (1)$$
$$M = M_{BP} - \Delta D_G + 0.22\,\Delta D_R \quad (2)$$
$$Y = Y_{BP} - 0.92\,\Delta D_B + 0.12\,\Delta D_G \quad (3)$$

where C_{BP}, M_{BP} and Y_{BP} are the basic packs for the average scene and $\Delta D_{R,G,B}$ are the density differences between the negatives of the particular scene and the average scene.

Equations (1), (2) and (3) may be converted to the following form for use with the computer:

$$C = -1.16\,\Delta D_R \quad (1')$$
$$M = -\Delta D_G - 0.19\,\Delta C \quad (2')$$
$$Y = -0.92\,\Delta D_B - 0.12\,\Delta M \quad (3')$$

where ΔC and ΔM are the changes in filter pack required to print a particular scene. The blue density of the cyan filter is neglected as this is a small factor over the filter ranges normally encountered. Thus, for example, the change in cyan CC filter required to compensate for a change in red integral density is 1.16 times as great as the change in integral density. Because of the unwanted absorptions of the filters, a further correction is required. Changing the cyan CC filtration induces a change in the required magenta filtration to compensate for the density to green light of the cyan CC filter. A similar compensation in the yellow CC filter pack is required whenever the magenta filter pack is changed, because of the absorption of blue light by the magenta filters.

Equations (1′), (2′) and (3′) suggest that a very simple computer employing the null principle can be used. The Wheatstone bridge (using linear potentiometers with properly scaled dials on the control knobs) embodies all the necessary requirements.

In Fig. 11, the schematic diagram of Fig. 2 has been redrawn as three separate Wheatstone bridges for ease of discussion

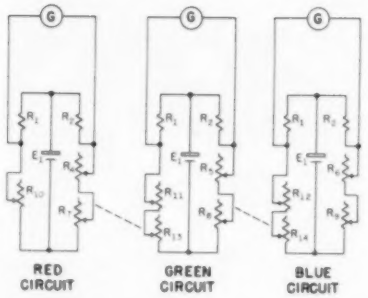


Fig. 11. Schematic diagram showing the three separate circuits of the computer.

and visualization of the principles of operation. The resistances in two of the legs of each bridge (R_1 and R_2) are equal. For balance, it is therefore required that the resistance in the other two legs of the bridge be equal to each other. The C, M, Y and R, G, B dials on the computer control single-turn linear potentiometers having the same resistance. The rulings on the dials, however, correspond to the constants in Eqs. (1′), (2′) and (3′). Thus, the C, M, Y and G dials have the same scales; a scale unit on the R dial has an angular subtense 1.16 times as great; and a unit on the B dial has angular spacing 0.92 times as great. By the use of this scaling on the dials, a displacement of one unit on the R dial will require a compensating displacement of 1.16 scale units on the C dial, as the equations require. A similar analysis applies to the remaining dials.

In order to introduce the interactions between the cyan and magenta filters and between the magenta and yellow filters, the shafts of the C and M potentiometers are linked mechanically to the shafts of potentiometers R_{13} and R_{14} respectively, as shown in the schematic diagram (Fig. 11). To obtain the desired relationship, two degrees of freedom are available. These are the linkage ratio and the ratio of resistance per unit angular displacement of the C potentiometer to R_{13} and of the M potentiometer to R_{14}. Thus in the case of the cyan-magenta interaction, each time the cyan potentiometer introduces a change of given magnitude, the equations require that a change 0.19 times as great be induced in potentiometer R_{13}. This might be accomplished by choosing a linkage ratio of 1:1 and having the resistance per turn of R_{13} be 0.19 times as great as that for the C potentiometer. However, it is important to note that any combination of linkage and resistance ratios having a product of approximately 0.2 would serve equally well. In the case of the magenta and yellow interaction, the same reasoning applies.

It is strongly recommended that all printing be done close to the initial stop-setting on the printer. In certain instances considerable departure from

the original setting will be necessary. In such instance the proper choice of stop-setting and CC filtration may be made with the aid of the *Printer Stop Dials*, a set of fixed outer dials concentric with the C M Y knobs. The increments on the dials are determined by the log exposures corresponding to various stop-settings for a given printer and are then modified by the primary constants of Eqs. (1′), (2′) and (3′). The scaling is such that any set of C, M, and Y values that appear under the same stop-setting on all three dials represents a satisfactory printing balance at that stop-setting. The use of this feature and actual calibration of the dials will be explained in subsequent sections.

Dials

Construction

The simplest way to compensate for the different coefficients of the functions, ΔD_R, ΔD_G and ΔD_B in Eqs. (1′), (2′) and (3′), is in the construction of the dials for the instrument. The size of the scale unit must be chosen such that the desired density range can be accommodated on each dial. A unit increment of 1.76 degrees per 0.01 density unit was chosen as being convenient for the green density dial. A range in density from 0.0 to 2.00 would require:

$$2.00 \times \frac{1.76^\circ}{0.01} = 352^\circ$$

which leaves $360^\circ - 352^\circ = 8^\circ$ dead space on the dial. The unit spacing for the other dials is calculated by multiplying the 1.76° unit by the factors in Table I, obtained from the coefficients of Eqs. (1′), (2′) and (3′).

If the integrated full-frame timing method is used, and if less than full correction[2,3] is desired, sets of red, green and blue input dials are required for each correction level. The scale increment for each input dial is reduced by the percentage of full correction desired; for example, for 90% correction the increments are 0.9 times the normal increments.

Arrangement

The input dials and the diaphragm-stop dials are fixed in position on the panel (Figs. 4 and 6). A pointer is attached to each input potentiometer shaft (R_4, R_5 and R_6 of Fig. 11).

The output dials are attached to their potentiometer shafts (R_7, R_8 and R_9). These dials overlie the diaphragm-stop dials (Figs. 6 and 7).

As seen from Table I, in going from subtractive to additive printing it is necessary to change the red input dial because the dial increments are different for the two cases. The blue input dials are sufficiently alike that little error will be introduced by using them interchangeably, and the green input dials are identical.

Table I. Factors for Calculating Dial Spacing.

Dial	Factor
Subtractive Printing	
Red density input	1.16
Green density input	1.0
Blue density input	0.92
Cyan output	1.0
Magenta output	1.0
Yellow output	1.0
Red diaphragm stop	1.16
Green diaphragm stop	1.0
Blue diaphragm stop	0.92
*Additive Printing**	
Red density input	1.0
Green density input	1.0
Blue density input	0.90
Red attenuator output	1.0
Green attenuator output	1.0
Blue attenuator output	1.0

* Except for the blue density input, all factors for additive printing are unity, as a one-for-one relationship exists between negative densities and printer beam attenuators. The blue factor of 0.90 accounts for the small differences between the way the negative is seen by the densitometer and by the Eastman Color Print Film.

For additive printing, red, green and blue attenuator dials are used for outputs. These attenuator dials, attached to the shafts of the output potentiometers, are read opposite a red dot placed above setting number 10 on each diaphragm-stop scale. All other markings on the diaphragm-stop scale are disregarded in additive printing (see Appendix II).

Scale Units

The scale divisions on the input dials are 0.02 density units. On the cyan, magenta and yellow output dials the scale divisions are 0.025, the units commonly used for CC filters. The diaphragm-stop scales are calibrated in terms of the Bell & Howell Printer, Model D, and then modified as required by the factors shown in Table I. The units on the attenuator dials for additive printing are 0.02 log E. Because of the limitations of the particular beam-attenuating device used on the additive printer, the range of these scales was limited to 0.62 log E units.

Parts of the Computer

The parts, with the code referring to Figs. 2 and 11, are listed in Table II. The function of each part is indicated.

APPENDIX II

Operating Instructions

Preparation

1. Measure through Status K filters the red, green and blue densities of the gray card in each scene of the original negative; OR — measure the red, green and blue integrated full-frame densities of a typical frame in each scene.

2. Print to an optimum balance one typical negative scene having gray-card (or full-frame) densities near the average for the feature to be timed. The printer variables for this typical scene are

Table II. Parts of the Computer.

Code	Component	Function
Resistors		
R_1, R_2	25-ohm, 1-w	Fixed bridge legs
R_3	4000-ohm, 1-w	Meter protection
R_4	500-ohm potentiometer	Red negative density input
R_5	500-ohm potentiometer	Green negative density input
R_6	500-ohm potentiometer	Blue negative density input
R_7	500-ohm potentiometer	Cyan filter output
R_8	500-ohm potentiometer	Magenta filter output
R_9	500-ohm potentiometer	Yellow filter output
R_{10}	1000-ohm potentiometer	Red set
R_{11}	1000-ohm potentiometer	Green set
R_{12}	1000-ohm potentiometer	Blue set
R_{13}	100-ohm potentiometer	Green density of cyan
R_{14}	50-ohm potentiometer	Blue density of magenta
Switches		
S_1	SPST	Sensitivity switch
S_2	DPST Momentary (N.O.)	Red circuit switch
S_3	DPST Momentary (N.O.)	Green circuit switch
S_4	DPST Momentary (N.O.)	Blue circuit switch
S_5	DPDT	Printer selection switch
Miscellaneous		
E_1 — 3-v battery		
G — Galvanometer, 500–0–500 μa, resistance approximately 50 ohms		
Chassis — Aluminum, 14-gauge, 13 × 17 × 4 in.		
Panel — Synthane, 13 × 17 × $\frac{1}{8}$ in.		

Notes

(1) All potentiometers have Standard Resistance Tolerance (±5%) and Standard Linearity Tolerance (±0.5%).
(2) Ten-turn potentiometers are desirable for R10, 11, 12 to provide good resolution.
(3) All other potentiometers are single-turn and may be continuous or with stop.
(4) R_7 and R_{12} are stacked or geared together 1 to 1.
(5) R_8 and R_{14} are stacked or geared together 1 to 1.

adjusted so that the optimum print is obtained at the mid-range of the printer timing mechanism.

Calibration

1. Dial Selection

a. Subtractive Printing. Use the set of dials prepared for use with Kodak Color Compensating Filters (C, M, Y).

b. Additive Printing. Use the set of dials prepared for use with the particular beam-attenuating device on the printer.

c. When full-frame rather than gray-card densitometry is used, less than full correction may be desirable.[3] In this case, the red, green and blue negative density input dials must be selected accordingly.

2. Printer Selection Switch. Put this switch in the subtractive or additive position as applicable.

3. Calculator Setup

a. Enter the red, green, and blue densities of the selected typical negative scene on the red, green, and blue input dials.

b. Enter on the C, M, and Y output dials opposite the correct printer diaphragm stop the filter values used for printing the typical negative scene. (Enter the red, green, and blue beam-attenuator values opposite the reference dot if additive printing is used.)

c. Obtain a zero meter reading on the red, green, and blue circuits in the following manner: (1) Put the sensitivity switch on "low." (2) Hold the red circuit switch closed until a zero meter reading is obtained by turning the red set knob. Similarly, the green and blue circuits are adjusted for a zero meter reading using the appropriate green and blue circuit switches and set knobs. (3) Put the sensitivity switch on "high." (4) Repeat step (2) above, making the final small adjustments of the set knobs that are necessary to obtain zero meter readings in the red, green, and blue circuits.

4. After this initial adjustment, the red, green and blue set knobs remain untouched until the print film, print process or printer is changed.

Timing Operation

1. Enter the negative densities of a scene on the red, green and blue negative density input dials.

2. With the sensitivity switch on "high," obtain a zero meter reading for the red, green and blue circuits by turning the cyan, magenta and yellow dials (in that order) for subtractive printing, or by turning the red, green and blue attenuator knobs for additive printing.

a. Subtractive Printing. Obtain a zero meter reading in the red circuit by holding the red circuit switch closed and turning the cyan dial until the meter reads zero. Follow an analogous procedure in balancing the green and blue circuits, making the successive zero adjustments in these cases with the magenta and yellow dials. It is essential that the circuits be balanced in the order red, green, blue.

b. Additive Printing. To make the zero adjustment in the red, green and blue circuits, manipulate the red, green and blue beam-attenuator dials in the same way as the cyan, magenta and yellow dials are manipulated in the procedure for subtractive printing.

3. Read and Record Data

a. Subtractive Printing. Record the predicted cyan, magenta and yellow filter values appearing opposite the diaphragm stop used in printing the typical negative scene. (This is the same diaphragm stop used in calibrating the calculator.) If the diaphragm stop falls below the zero point of any filter scale, choose the filter values that are found opposite the smallest diaphragm stop *common* to all three filter scales.

b. Additive Printing. Record the required red, green, and blue beam-attenuation levels appearing opposite the reference dots. If a reference dot falls off either end of an attenuator scale, the basic printer light level must be adjusted for that scene.

Use of Data

1. Subtractive Printing. The filter values for each scene are obtained directly from the calculator, but the diaphragm stop must be modified according to the total *number* of filters in the pack. The two interfaces of each filter have the same effect as a neutral density of 0.04, which is approximately equal to the increase in log E per diaphragm stop on the Bell & Howell, Model D Printer. The diaphragm setting for each scene must therefore be adjusted up or down, according to the number of filters by which the new pack exceeds or falls short of the pack of the preselected typical scene. When a scene requires a filter pack containing three more filters than the typical scene, the diaphragm setting must be increased three stops; two less filters, decreased two stops, etc. This calculation can be done quickly at the time the filter values are being recorded.

2. Additive Printing. Beam-attenuator settings are read directly from the calculator without modification.

References

1. G. T. Keene, "A color timing calculator for subtractive motion-picture printers," *Jour. SMPTE, 67:* 404–408, June 1958.
2. J. G. Stott, W. R. Weller and J. E. Jackson, "Automatic timing of color negatives," *Jour. SMPTE, 65:* 216–221, Apr. 1956.
3. C. J. Bartleson and R. W. Huboi, "Exposure determination methods for color printing: the concept of optimum correction level," *Jour. SMPTE, 65:* 205–215, Apr. 1956.

Ed. Note: At the Convention a motion picture was shown to illustrate the timing results on a 400-ft test roll.

Discussion

Lewis Humphrey (Moody Institute of Science): Has there been any adaptation of this method to timing Kodachrome?

Deane S. Thomas (Eastman Kodak Co.): Not so far. Kodachrome is often considered so much more easily timed than color negatives, that a good first print is normal in many laboratories with Kodachrome. There is no reason whatever why this technique could not be used in the same way with equal success by anyone who wished to do so with Kodachrome or any other original material. Of course, some modification of the dials and gear linkage would be needed for different combinations of original films, print films, and densitometry.

Errata

George T. Keene, "A Color Timing Method and Calculator for Subtractive Motion-Picture Printers," *Jour. SMPTE, 67:* 404–408, June 1958.

On page 408, column 2, lines 11 and 12, *read:* Fortunately, the red-light absorption of the magenta filters is negligible *for* Fortunately, the blue-light absorption of the magenta filters are negligible.

D. W. Fassett, F. J. Kolb, Jr., and E. M. Weigel, "Practical Film Cleaning for Safety and Effectiveness," *Jour. SMPTE, 67:* 572–589, Sept. 1958.

On page 577, Table II, in the tenth column across the top from left to right, *read:* Personnel Hazard *for* Personnel sonnel Hazard; in Item No. 1, *n*-Butyl chloride, under the column Personnel Hazard, *read:* Mod. *for* None.

Subtractive Color Printer With Geneva Scene-Change Mechanism

By HARRY BRUEGGEMANN

The use of a subtractive color printer in a commercial laboratory is desirable, chiefly because of economic considerations, provided high standards of reliability are maintained. A scene-change system is described which uses a Geneva movement to turn a sprocket which then moves a color filter matte. The action transports the matte smoothly and reliably.

In principle, an additive-type color printer can produce a better quality print, faster, and at less operating cost, than can a subtractive-type printer. It may seem that there is no point in building subtractive printers, but there are still many things in their favor.

The initial cost of a subtractive printer is less than that of an additive printer. This is an important consideration for a commercial laboratory, where the cost of the equipment must be written off against the product produced. Also, additive printers are still undergoing major design changes, and a printer purchased now may be obsolete before it has paid for itself. In the author's opinion, at the present stage of design additive printers are not as reliable as subtractive printers. Pathé Laboratories has a large investment in subtractive printers. Adding a system of additive printers requires abandoning all of the subtractive printers, an expensive move. Or, if the conversion is made gradually, a duplicate system of timing and print preparation is required, consequently doubling the cost of timing. In other words, the two types of printers are not compatible.

Pathé Laboratories has some high-speed subtractive color printers, used for printing color release. These printers can process five 2000-ft rolls per hour, at the rate of 200 ft/min, with two or three minutes required to change raw stock. This speed can be attained on release only after the customer has approved the answer print, and making an acceptable answer print is a slow and costly process. It is undesirable economically to tie up the fast printers on answer print work.

With this specific problem in mind, Pathé Laboratories undertook to design a subtractive color printer which would use the color scene-change system of the high-speed printer and at the same time be as simple on negative thread-up as a Bell & Howell Model D Printer. The construction cost was to be kept at a minimum. The printer was to be used to make color answer prints, and when the answer was approved by the customer, the scene-change mattes would be moved to the high-speed printer and release printing would begin.

The scene-change system of the high-speed printer consists of a piece of clear 35mm leader, with the appropriate color filters for each scene stapled on it. This assembly of leader and filters is called the color scene-change matte. Determining color and density of these filters is done during the making of the answer print. The filters remain in the light path while the scene is being printed. When the arrival of the next scene is signalled by the cuing system, the matte is moved so that the next group of filters is placed in the light path. This action must take place swiftly and smoothly, and at the exact instant that the scene change is in the printing aperture. In order to avoid "flashes" at the scene change, the separation between the outgoing and the incoming filters of the matte must be as small as possible, neither opaque nor transparent, and the image of this separation on the printing stock must fall at the scene change and travel at the same speed as the film.

Design of the Printer

Because of the restriction on construction cost and the requirement for simplicity of thread-up, a Bell & Howell Model D Printer was chosen as the basic unit. The scene-change system of the high-speed printer was not adaptable to the Bell & Howell printer, because of its dimensions. It was also felt that the design of the matte-transport system, which is a torque motor, could be improved. The torque motor is coupled to the matte-transport sprocket and held stationary by a ratchet. This ratchet is released by the scene-change cuing system and stopped again when the next scene filters are in place. Operating the torque motor at the stalled condition in this manner produces only a small amount of power for moving the matte mechanism. Moving the matte by direct solenoid drive to provide a more positive motion was considered; but the deceleration at the completion of the cycle is very high, resulting in matte damage and excessive wear on the mechanism.

A Geneva movement seemed the answer to this problem. The speed of operation is very high, yet the accelerations are not very large. In the final design, the pinwheel of the Geneva is driven by a solenoid, and the star wheel turns the sprocket which transports the matte (Fig. 1).

For optical reasons, which will be explained later, the matte had to be located in the optical path at the point where the butterfly head meets the lamphouse. In order to make the image of the matte on the film travel with the film during the scene change, the matte had to be transported downward. It would have been very convenient to locate the matte sprocket above the printer, but film cannot be pushed through a guide; it must be pulled. This necessitated placing the sprocket below the lamphouse (Fig. 2). In order to allow the matte to be made into a loop, it was guided through the base of the lamphouse, then around the lamphouse to the starting point. The sprocket itself is a 48-tooth sprocket, but 32 teeth have been removed for clearance of the filters and staples. The color matte filters span six teeth, so that eight matte frames circle the sprocket, which rotates 45° per scene change, and a two-to-one reduction system of hardened helical gears is used to connect it to the Geneva. Figure 3 is a rear view of the printer showing the main support block mounted on the rear of the lamphouse. All of these photographs were made with the safety cover removed.

Optical System

A standard Bell & Howell high-intensity lamp, at first considered as the printing light source, could not be used because of the light-changing system incorporated with the color scene-change matte. In addition to modulating the color of the printing light, the matte also modulates the density. This is done by stapling over the color filters a piece of film that is partially opaque and partially transparent. The percentage of the area that is transparent determines the intensity of the printing light. Thus the light matte, as it is called, is in principle the same as the iris of a camera and, like an iris, must be at a nodal point of the optical system. A nodal point is not available at the proper location in the high-intensity lamp; therefore, an optical system had to be designed.

The optics, chosen so that replacements would be economical and available, consist of components from the

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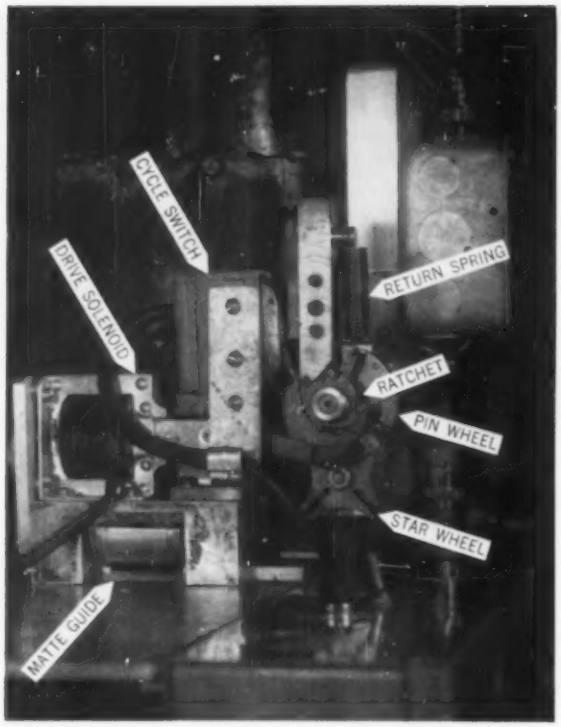

Fig. 1. A Geneva movement showing the drive solenoid, ratchet, pinwheel, star wheel, deceleration and return spring, and cycle completion switch. The exit portion of the matte guide is shown below the solenoid.

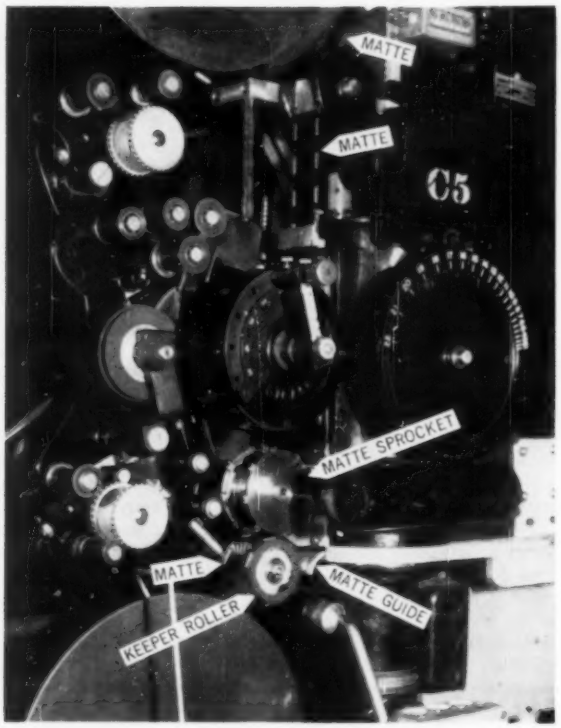

Fig. 2. The path of the matte is shown. Starting at the idler roller above the lamphouse, the matte travels vertically downward to the matte sprocket, turns 90° around this sprocket, then 200° around the keeper roller and through the base of the lamphouse.

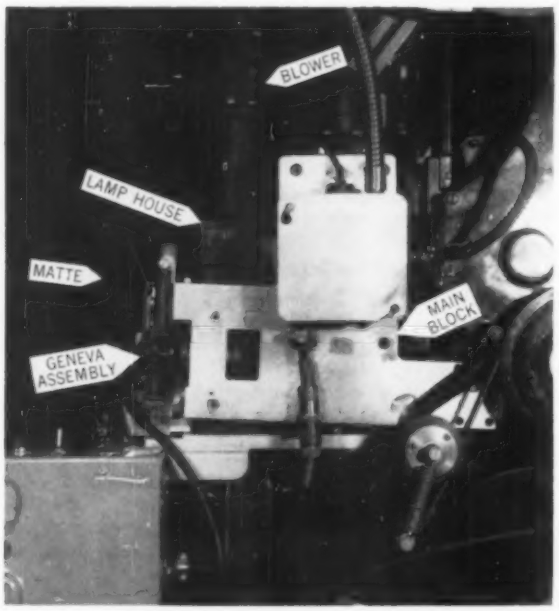

Fig. 3. The entire Geneva and sprocket assembly is tilted 3° from horizontal to allow clearance for the matte guide, which runs below the lamphouse and drive solenoid.

Kodak Master Slide Projector, plus the negative lens prism from the Bell & Howell high-intensity light source. The prism has two functions: first, to deflect the printing light 15° as required by the Bell & Howell printing sprocket; and second, to produce an anamorphic image at the printing aperture and thereby cover the rectangular aperture efficiently.

As installed in the printer, the optical system produces a flat field with all 21 light mattes. Using a 750-w lamp, and with as many as nine filters on the color scene-change matte, there is enough exposure for color film at a printing speed of 60 ft/min.

Assembly of the color scene-change mattes requires a considerable amount of time, and is the primary reason why it is not economical to use this printer for single print orders. To minimize the assembly time, a matte assembly station has been arranged. This station is built around the foot stapling machine which affixes the matte filters to the clear leader. In this grouping is a filter punch, which punches filters into the proper shape for the matte. Quantities of filters are prepunched and stored in racks arranged around the foot-stapler, every filter being within reach of the matte assembling operator. Also, there is a "filter stapler," which is composed of a leader guide with register pins, and a filter locating guide, all built around the stapler head. This arrangement makes alignment of the filters on the clear leader stock quick and precise. To make up the filters as required by the timing sheet, these

filters are taken from the rack, located on the leader stock, stapled, and the leader is advanced to the next position. This procedure requires 12 to 25 sec per scene.

Changing raw stocks during the printing of the release is avoided wherever possible by production scheduling; however, if it does become necessary, a "pull-back" test is made on the new stock, and the indicated changes are made in the basic filter pack.

The goal throughout the design and construction of this printer was reliability, successfully demonstrated when the first job was put on the printer. A 200-ft color trailer was timed and 150 prints made with no down time for other than routine maintenance. In addition to its original function as a timing accessory to the high-speed printer, the Geneva printer has proven useful for short footage jobs, and has been earning its keep.

An Annotated List of Articles Pertaining to the History of Motion Pictures — 1950–1956

By MILDRED B. KRAINOCK

(Including Some Historical References on Television)

In compiling this bibliography, two types of material were considered: (1) items describing early equipment, or contributions of an individual to the early development of motion pictures; and (2) items describing new equipment, process or system for cinematography. The sources used include: *American Cinematographer*, *British Kinematography*, *Image* (published by the George Eastman House, Rochester, New York, since 1952), *Journal of the Society of Motion Picture and Television Engineers*, and the *Monthly Abstract Bulletin* (published by Kodak Research Laboratories). The list is not intended to cover the subject completely but is believed to include many of the major references.

I. CAMERAS AND PROJECTORS

1. Card, J., "The George K. Spoor Collection," *Image, 5, No. 8:* 182–185, Oct. 1956. A collection of motion-picture film and equipment.
2. Cricks, R. H., "Design of Modern Cine Cameras," *Functional Phot., 3:* 11–13, June 1952. Evolution and design of professional motion-picture cameras.
3. Daily, C. R., "New Paramount Lightweight Horizontal-Movement VistaVision Camera," *Jour. SMPTE, 65:* 279–281, May 1956. Describes a portable camera for use on locations to film VistaVision features; it weighs 17½ lb and accommodates a 400-ft reel of film.
4. Doublier, F., "Reminiscences of an Early Motion Picture Operator," *Image, 5:* 134–135, June 1956. A lecture given October 15, 1941, at New York University.
5. Gavin, A. E., "Tomorrow's Wide-Screen Camera. . .," *Am. Cinemat., 35:* 174–176, 202–204, Apr. 1954. Discusses development of the VistaVision system by Paramount Pictures Corp.
6. Gavin, A. E., "CinemaScope on 55 Film," *Am. Cinemat., 36:* 582–583, 610, Oct. 1955. Describes a wide-screen system developed by Twentieth Century-Fox Films Corp.
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8. Hill, G., "Motion Picture Camera Development," *Brit. Kinemat., 17, No. 4:* 105–117, Oct. 1950. A review of apparatus.
9. Kotte, J. J., "Cinema Projector for 70mm and 35mm Films," *Philips Tech. Rev., 17:* 299–302, Apr. 1956. Describes the Philips projector EL 4000, manufactured specially for the Todd-AO system.
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11. Pierschel, G., "State of Development of Picture Projectors and Sound-Picture Projectors for 16-mm Film," *Bild u. Ton, 6:* 46–51, Feb. 1953. Review of apparatus.
12. "Technicolor Offers 'Technirama'," a New System of Large-Screen Projection," *Mot. Pic. Herald, 207, No. 12:* 27, Sept. 22, 1956. Describes a large-screen projection system. The film moves through the camera horizontally, exposing pictures having eight perforations per frame.

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13. Allen, L., "New Technicolor System Tested by Directors of Photography," *Am. Cinemat., 31:* 414, 424, Dec. 1950. Discusses low light-level system of motion-picture photography.
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17. Craig, G. J., "Eastman Colour Films for Motion Picture Work," *Brit. Kinemat., 22:* 146–158, May 1953. Describes four new films for color motion-picture photography.
18. Cricks, R. H., "The French Film in Britain," Suppl. *Kinemat. Weekly, 431:* 15, Feb. 19, 1953. Reviews color motion-picture industry in France; companies, processes, etc., are mentioned.
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20. Duerr, H. H., "The Ansco Color Negative-Positive Process," *Jour. SMPTE, 58:* 465–470, June 1952. Describes film and process.
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22. Foster, F., "Eastman Negative-Positive Color Films for Motion Pictures," *Am. Cinemat., 34:* 322–323, 348–349, July 1953. Describes a single-camera original film and the associated films for use in color motion pictures.
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26. Hanson, W. T., Jr., "Color Negative and Color Positive Film for Motion-Picture Use," *Jour. SMPTE, 58:* 223–238, Mar. 1952. Describes two new multilayer color films.
27. Mitchell, R. A., "The New Ansco Color Film and Process," *Am. Cinemat., 34:* 166, 177–183, Apr. 1953. General discussion; processing procedure not given.
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This list of articles was prepared under the direction of Dr. Walter Clark as a contribution of the Society's Historical and Museum Committee, by Mildred B. Krainock, Dept. of Information Services, Research Laboratories, Eastman Kodak Co., Rochester 4, N. Y. (This compilation was received on May 15, 1958.)

30. Rowan, A., " 'The Wild North' Introduces MGM's New Ansco Color Process," *Am. Cinemat., 33:* 106–107, 122–124, Mar. 1952. Discusses Ansco's single-negative color film.
31. "Current Techniques of 35mm Color Film Photography and Printing," *Am. Cinemat., 37:* 26–27, 58, Jan. 1956. A survey.
32. "Historic Camera for Museum," *Kinemat. Weekly, 418:* 10, Jan. 3, 1952. First Kinemacolor camera was given by Dufay-Chromex Ltd., to Science Museum.
33. "New Eastman Color Film Tested by Hollywood Studios and Film Labs," *Am. Cinemat., 31:* 95, 102, Mar. 1950. Discusses tests of a single-negative, single-positive color system.
34. "Technicolor to Record Elizabeth's Coronation," *Technicolor News and Views, 15, No. 1:* 2, 8, Apr. 1953. Describes plans for making the first complete color motion picture of the Coronation ceremony.
35. "Innovation in the Motion-Picture Technical Industry: New Photocells for Color Sound Films," *Kino-Technik, 6:* 75, Apr. 1952.
36. "New Color Deal," *Am. Cinemat., 33:* 206, 215–216, Mar. 1952. Documentary film, "Royal Journey," gives cinematographers an opportunity to use and evaluate Eastman Color Negative Film.
37. "Colour at the Cinema," *Brit. J. Phot., 99:* 447–448, Sept. 12, 1952. First use of Eastman Color Negative Film; a feature made on Ansco Color Negative; early use of several new film products or processes.

III. EARLY DEVICES

38. Bowen, H. G., "Thomas Alva Edison's Early Motion-Picture Experiments," *Jour. SMPTE, 64:* 508–514, Sept. 1955. Historical objects, documents, photographs and prints from early motion pictures recently released by the archives of Thomas A. Edison Foundation and Museum.
39. Card, J., "From Muybridge to CinemaScope," *Image, 3:* 15–16, Feb. 1954.
40. Card, J., "The George K. Spoor Collection," *Image, 5, No. 8:* 182–185 Oct. 1956. A collection of early motion-picture film and equipment.
41. Card, J., "The Mystery of Molteni's Choreutoscope," *Image, 5, No. 10:* Dec. 1956. A description of an early device.
42. Coe, B. W., "Appreciation of the Origins of Cinematography," *Brit. Kinemat., 27, No. 6:* 171–183, Dec. 1955.

42a. Coulson, T., "Philadelphia and the Development of the Motion Picture," *J. Franklin Inst., 262:* 1–16, July 1956. Describes Sellers' Kinematoscope (1860), Heyl's Phasmatrope (1870), and the work of Muybridge (1883 —) and other pioneers.

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44. Michaelis, A. R., "E. J. Marey — Physiologist and First Cinematographer," *Brit. J. Phot., 102:* 598–601, Dec. 2, 1955. Marey, a physiologist, was a student of animal movement who used first a series of images on a circular glass plate, then a flexible piece of film exposed through a rotating shutter to give the illusion of movement.
45. Newhall, B., "Muybridge and the First Motion Picture. The Horse in the History of the Movies," *Image, 5:* 4–11, Jan. 1956.
46. "Mr. Edison's Kinetoscope," *Image, 1:* 2, Mar. 1952.

46a. Tümmel, H., "History of Cinematography. Pts. I–VI," *Kino-Technik, 9, No. 1:* 21–22, 1955; *9, No. 2:* 52, 54, 1955; *9, No. 7:* 252, 254, 1955; *9, No. 8:* 286, 288, 290, 1955; *10, No. 6:* 230, 231, 1956; *11, No. 1:* 22, 23, 1957. Describes various devices for recording images simulating motion from the 16th century to the late 19th century; numerous illustrations, literature references.

47. Veronesi, G., "The Sixtieth Anniversary of Motion Picture [Celebrated] in Paris Exposition," *Ferrania, 9:* 22–24, Oct. 1955. Describes the exposition held to celebrate 60 years of motion pictures.
48. "Sixty Years of German Film," *Kino-Technik, 9, No. 11* (Special Issue): 379–456, Nov. 1955. The whole issue covers different phases of motion-picture development.

IV. EQUIPMENT FOR 16MM CINEMATOGRAPHY

49. Allen, L., "Eleven Cameras for Circarama," *Am. Cinemat., 36:* 476, 485–486, Aug. 1955. Describes camera and projector arrangement for circular screen motion picture used in Disneyland exhibit.
50. Deschin, J., "50 Years of Amateur Movies," *Modern Phot., 15:* 75–77, 82, Apr. 1951. Growth of amateur motion pictures, significant developments and accomplishments are discussed; illustrations of early cameras and projectors included.
51. Matthews, G. E., and Tarkington, R. G., "Early History of Amateur Motion-Picture Film," *Jour. SMPTE, 64:* 105–115, Mar. 1955. Describes history of 16mm, 9.5 mm, and 8mm film processes.
52. Moses, A., "Trends of 16mm Projector Equipment in the Army," *Jour. SMPTE, 55:* 525–535, Nov. 1950. Reviews Army's use of 16mm motion pictures for last decade, describes present equipment and standards.
53. Victor, A. F., "The First Quarter Century of Victor Animatograph," *Film News, 3:* 20–21, June–July 1948. An account of A. F. Victor's work, particularly design and manufacture of 16mm cameras and projectors; also an account of development of 16mm cinematography.

V. FILMS AND EMULSIONS

54. Capstaff, J. G., "An Experimental 35mm Multilayer Stripping Negative Film," *Jour. SMPTE, 54:* 445–458, Apr. 1950.
55. Handley, C. W., "History of Motion-Picture Studio Lighting," *Jour. SMPTE, 63:* 129–133, Oct. 1954.
56. Lindgren, E., "Preserving History in Celluloid," *Kinemat. Weekly, 469:* 57–58, 63, May 3, 1956. The National Film Archive was founded in 1935 to preserve films of historical importance — either as to subject matter or techniques employed in making the film.
57. "New Kodak Film Takes Movies in the Dark," *Photo Dealer, 18:* 113, Sept. 1952. Describes Kodak Spectroscopic 1-N Film.

VI. FILM SUPPORTS

58. Benson, J., "Without Celluloid There Would Have Been No Film Industry," *Ideal Kinema* (Suppl. to *Kinemat. Weekly*), *16:* 25, Apr. 13, 1950. A short history of the use of celluloid and the research for safety film.
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60. Matthews, G. E., and Tarkington, R. G., "Early History of Amateur Motion-Picture Film," *Jour. SMPTE, 64:* 105–115, Mar. 1955. Describes history of 16mm, 9.5-mm, and 8mm film processes.
61. "Toughest, Thinnest Film. . .," *Am. Cinemat., 36:* 646–647, Nov. 1955. Discusses du Pont's Cronar polyester film.

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62. Beard, M., "High-Speed Photography in Science and Industry," *PSA Journ., 18A:* 476–477, 488, Aug. 1952. A review of high-speed cameras; examples of application.
63. Chesterman, W. D., "History and Present Position of High-Speed Photography in Great Britain," *Jour. SMPTE, 60:* 240–246, Mar. 1953. Gives history and describes recent developments.
64. Prime, H. A., "High Speed Photographic Techniques," *Australian J. Instr. Technol., 11, No. 4:* 145–158, Nov. 1955. Reviews various techniques for high-speed photography.
65. Garvin, E. L., "Bibliography on High-Speed Photography," *Jour. SMPTE, 56:* 93–111, Jan. 1951.
66. Schardin, H., "The Development of High-Speed Photography in Europe," *Jour. SMPTE, 61:* 273–285, Sept. 1953.
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VIII. PIONEERS IN MOTION PICTURES

71. Bowen, H. G., "Thomas Alva Edison's Early Motion-Picture Experiments," *Jour. SMPTE, 64:* 508–514, Sept. 1955. Historical objects, documents, photographs and prints from early motion pictures recently released by the archives of Thomas A. Edison Foundation and Museum.
72. Coe, B. W., "The Truth About Friese-Greene," *Brit. J. Phot., 102:* 446–448, Sept. 9, 1955.
73. Coe, B. W., "Appreciations of the Origins of Cinematography," *Brit. Kinemat., 27, No. 6:* 171–183, Dec. 1955.
74. Cricks, R. H., "Study of William Friese-Greene's Place in the Invention of Kinematography," *Cine-Technician, 16:* 94–100, July–Aug. 1950.
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79. Symons, K. C. M., and Dudley, H. J., "A Hundred Years of Stereoscopy," *Miniature Camera Mag., 14:* 467–472, Aug. 1950.
80. Tuttle, H. B., and Matthews, G. E., "The Father of Home Movies," *PSA Journ., 18A:* 418–420, July 1952. Reviews life work of J. G. Capstaff.
81. Veronesi, G., "The Sixtieth Anniversary of Motion Picture [Celebrated] in Paris Exposition," *Ferrania, 9:* 22–24, Oct. 1955. Describes the exposition held to celebrate 60 years of motion pictures.
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83. "August Lumière," *Brit. J. Phot., 101:* 198, Apr. 18, 1954. A review of the work of August Lumière.

IX. PROCESSING AND PRINTING TECHNIQUES

84. Goldhammer, J. S., "Some Design Features of a Wide-Film Continuous Processing Machine," *PSA Journ., Phot. Sci. Tech., 19B, No. 1:* 32–36, Feb. 1953. Description of USAAF Type A-9 Processing Machine developed from the Kodak Limited Continuous Film Processor and the Williamson Multiprinter.
85. "Current Techniques of 35 mm and Color Film Photography and Printing," *Am. Cinemat., 37:* 26–27, 58, Jan. 1956. A survey.

X. PHOTOGRAPHIC TECHNIQUE

86. Black, H., "45 Years in Cinematography," *Am. Cinemat., 34:* 24, 31–33, Jan. 1955. Arthur Miller recalls some significant developments that influenced cinematography.
87. Cricks, R. H., "Early Days of Animated Pictures," *Functional Phot., 4, No. 6:* 14–16, 27, Mar. 1953. The early days of the cinematographic industry are surveyed.
88. Dunning, C., "Time-Lapse Cinematography," *Am. Cinemat., 36:* 228, Apr. 1955. Discusses industrial and scientific applications of time-lapse motion-picture photography.
89. Mees, C. E. K., "History of Professional Black-and-White Motion-Picture Film," *Jour. SMPTE, 63:* 134–137, Oct. 1954.
90. Rowan, A., " 'Anistration' — Streamlined Animation Technique," *Am. Cinemat., 33:* 340–341, 354, Aug. 1952. Discusses a method of animation developed by R. G. Wolff.
91. Selle, W., "Polarized Light in Motion-Picture Technique," *Kino-Technik, 5:* 66–68, 69, Apr. 1951. Application of sheet polarizers to motion-picture techniques.
92. "Aspherics Promise Faster Cine Lenses," *Am. Cinemat., 37:* 246–249, Apr. 1956. Describes aspheric lens elements and their use in cinematography.
93. "The Trend to Wider Motion Picture Negatives," *Am. Cinemat., 36:* 332–333, 368, June 1955. A survey of processes being used and investigated.

XI. PRODUCTION OF MOTION PICTURES

94. Card, J., "The George K. Spoor Collection," *Image, 5, No. 8:* 182–185, Oct. 1956. A collection of early motion-picture film and equipment.
95. Cricks, R. H., "History and Development of the Colour Film," *Brit. Kinemat., 17, No. 2:* 57–59, Aug. 1950.
96. Thomas, H., Gordon, K., and Bland, W. S., "Evolution of the Newsreel." I. Introduction (Thomas); II. The Early Days of Newsreels (Gordon); III. The Development of Sound Newsreels (Bland); IV. The Future of Newsreels (Thomas), *Brit. Kinemat., 17, No. 2:* 46–56, Aug. 1950.
97. Walsh, A., "Thirty Years of Film Production," *Brit. J. Phot., 96:* 312–313, July 8, 1949. Report of a speech given by Sir Michael Balcon at a joint meeting of the British Kinematograph Society and the Association of Cine Technicians.

XII. PROGRESS IN MOTION PICTURES AND TELEVISION

98. Abramson, A., "Short History of Television Recording," *Jour. SMPTE, 64:* 72–76, Feb. 1955. Described development of the three basic television recording processes since 1927.
99. Black, H., "45 Years in Cinematography," *Am. Cinemat., 34:* 24, 31–33, Jan. 1953. Arthur Miller recalls some of the significant developments that influenced cinematography.
100. Card, J., "From Muybridge to CinemaScope," *Image, 3:* 15–16, Feb. 1954.
101. Cricks, R. H., "A Year's Progress in Kinematography," *Phot. J., 92B:* 60–63, Mar.–Apr. 1952. Review and list of references.
102. Cricks, R. H., "Twenty-Five Years of Progress," *Brit. Kinemat., 29, No. 4:* 115–119, Oct. 1956.
103. Cricks, R. H., "The Technicolor Way," *Studio Rev.* (Suppl. to *Kinemat. Weekly, 420,* Mar. 27, 1952), pp. 5, 14, Mar. 1952. Discusses problems and development of the Technicolor process.
104. Gavin, A. E., "Technical Progress in 1954," *Am. Cinemat., 36,* 24–25, 42–44, Jan. 1955. Reviews changes and developments in the motion-picture industry brought about by such innovations as Cinerama and CinemaScope.
105. Hogan, J. V. L., "The Early Days of Television (1875–1930)," *Jour. SMPTE, 63:* 169–173, Nov. 1954. Traces significant steps.
106. Honri, B., "Twenty-Five Years — On," *Brit. Kinemat., 29, No. 4:* 120–122, Oct. 1956.
107. James, T. H., "Photographic Progress in 1953," *New International Year Book,* H. E. Vizetelly, Editor, Events of 1953, Funk and Wagnalls, New York, 1954, pp. 406–411; *Ibid.*, 1954, pp. 398–402; *Ibid.*, 1955, pp. 391–395; *Ibid.*, 1956, pp. 385–389.
108. Matthews, G. E., "Photographic Progress in 1950," *New International Year Book,* H. E. Vizetelly, Editor, Events of 1950, Funk and Wagnalls Co., New York, 1951, pp. 438–445; *Ibid.*, 1951, pp. 363–470; *Ibid.*, 1952, pp. 420–426.
109. Jensen, A. G., "The Evolution of Modern Television (1930–1954)," *Jour. SMPTE, 63:* 174–188, Nov. 1954. An account of major developments leading to modern television equipment.
110. Kremer, J., "Milestones in Design: The Motion Picture," *Machine Design, 23:* 154–157, Feb. 1951. A brief description of old and modern motion-picture devices.
111. Matthews, G. E., "Technical Highlights of the Past 50 Years," *Am. Phot., 45:* 93–100, 116, Feb. 1951.
112. Wratten, I. D., "Some Fields Covered by the Motion Pictures," *Phot. J., 92A:* 1–7, Jan. 1952. Surveys field of motion-picture activity from early times up to the present.
113. "Sixty Years of German Film," *Kino-Technik, 9* (Special Issue): 379–456, Nov. 1955. The whole issue of the journal covers different phases of motion-picture development.
114. "Sixty Years of Cinematography," *Brit. Kinemat., 28:* 99, Mar.; *28:* 145–146, May 1956.

XIII. SCIENTIFIC, EDUCATIONAL AND INDUSTRIAL APPLICATIONS

115. Jones, G. A., "The Film in Scientific Research," *Brit. Sci. News, 2, No. 20:* 235–238, 1949. A survey of important applications of photography, e.g. high-speed cinematography, to industry.
116. Duke, C. W., "Medicine Pioneers Color Video," *Business Screen Mag., 10, No. 7:* 24–26, 1949. Report of a demonstration at the American Medical Association.
117. Jones, G. A., "16mm in Scientific and Industrial Research," *Film User Year Book, 1950, Vol. 2,* B. Dolman, editor. Motion-picture photography as a scientific tool is discussed, and an international committee has been set up to study the work.
118. Lester, H. M., "The Motion-Picture Camera in Science and Industry," *Am. Ann. Phot., 64:* 74–80, 1950. Discusses high-speed motion-picture camera; several phases of work in science and industry are reviewed.
119. Matthews, G. E., "Photography in Industry and Science," *Am. Ann. Phot., 64:* 50–69, 1950. Describes four types of photographic records and a number of applications of photography.
120. Michaelis, A. R., "Films and Scientific Research," *Discovery, 11:* 111–115, Apr. 1950. Motion-picture techniques used as research tools in various scientific research fields.
121. "The Scientific Film Association Conference — Hastings, 4th–6th April: Some Applications of Technical Cinematography," *Brit. J. Phot., 99:* 245–246, May 23, 1952. Describes a number of technical applications and gives a historical survey.

XIV. SOUND RECORDING AND REPRODUCTION (OPTICAL AND MAGNETIC)

122. Bowen, A., Moir, J., and Turner, H., "Sound-Film Equipment in the Festival of Britain Telekinema," *Brit. Kinemat., 18:* 142–149, May 1951. Extensive details given of projection equipment for stereoscopic system and stereophonic sound system.
123. Clarke, W. H., "Magnetic Recording — A Progress Report," *Brit. Kinemat., 20:* 106, 109–113, Apr. 1952. Describes equipment soon to be available for motion-picture production studios.
124. Cricks, R. H., "First Telekinema Program," *Ideal Kinema* (Suppl. to *Kinemat. Weekly*), *17, No. 189:* 11, May 17, 1951. Describes stereoscopic and stereophonic films in the Telekinema.
125. Goldsmith, L. T. (Chairman), "Characteristics of Color Film Sound Tracks," *Jour. SMPTE, 54:* 377–378, Mar. 1950. A chart describes 16- and 35mm color sound film; this is part of the Subcommittee's study of color-sound films.
126. Hagemann, W., "Sound for the Picture," *Bild u. Ton, 3:* 138–141, May 1950. Review of different methods or sound recording on film.
127. Kellogg, E. W., "History of Sound Motion Pictures," *Jour. SMPTE, 64:* 291–302, 356–374, 422–437, June, July, Aug. 1955. A chronology is given of the conception and perfection of recorded sound as an adjunct to motion pictures.

128. Pierschel, G., "State of Development of Picture Projectors and Sound-Picture Projectors for 16mm Film," *Bild u. Ton, 6:* 46–51, Feb. 1953. Review of apparatus.
129. Ryder, L. L., "A New Method of Handling Sound for Foreign Releases," *Am. Cinemat., 33:* 158, 169–170, Apr. 1952. Magnetic sound in one language can be erased and replaced by another on the same release print.
130. Watkins, A. W., "Stereophonic Sound," *Brit. Kinemat., 24:* 64–71, Mar. 1954.
131. Moir, J., "Stereophonic Sound Reproduction in the Cinema," *Brit. Kinemat., 24:* 161–168, June 1954.
132. Watkins, S., "The Talking Film After Twenty Years," *Tech. cinématographique, No. 28:* 576–577, Oct. 3, 1946. An account of work by Bell Telephone Co. and subsidiaries in development of sound for motion pictures.
133. "Innovations in the Motion-Picture Technical Industry: New Photocells for Color Sound Films," *Kino-Technik, 6:* 75, Apr. 1952.
134. "Here Is Magnetic Sound," *U. S. Camera, 15:* 74–76, Apr. 1952. Describes principles and development of magnetic sound.

XV. SPECIALIZED APPLICATIONS OF MOTION PICTURES

135. Allen, L., "Eleven Cameras for Circarama," *Am. Cinemat., 36:* 476, 485–486, Aug. 1955. Describes camera and projector arrangement for a complete circle motion picture used for a Disneyland exhibit.
136. Dragesco, J., "Microcinematographic Technique in Great Britain," *Microscopie, 2, No. 2* (Pt. 2 — Mémoires): 109–112, Aug. 1950. Equipment of Canti, Hughes, Swann, Mitchison and Weston are reviewed; photographs.
137. Dugan, J., "The Cousteau Bathygraf: A Preliminary Report," *Phot. Eng., 2, No. 1:* 26–31, 1951. New motion-picture camera for undersea use.
138. Pruess, L. E., and Watson, J. H. L., "A Technique for Taking Motion Pictures of Electron-Microscope Images," *J. Appl. Phys., 21:* 902–903, Sept. 1950.
139. Michaelis, A. R., "Research Films," *Brit. J. Phot., 103:* 52–57, Feb. 3, 1957. Traces history of motion-picture camera for biological, pathological and medical studies.
140. Rebikoff, D., "Underwater Motion Pictures in Color," *La Photographe, 43, No. 793:* 214–216, June 5, 1953; *Ibid., 43, No. 794:* 246–248, June 20, 1953. Describes equipment, methods and work.
141. Rebikoff, D., "Underwater Color Cinematography," *Jour. SMPTE, 63:* 55–60, Aug. 1954. Describes author's invention, the "torpedo" camera.
142. Stobart, T., "On Mount Everest With 16-mm Film," *Film User, 7, No. 82:* 424–426, Aug. 1953. Official photographer describes making the record of the 1953 Mount Everest Expedition.
143. Weinberg, S. A., Watson, J. S., Gramiak, R., and Ramsey, G. H., "Stereo-X-Ray Motion Pictures," *Jour. SMPTE, 62:* 377–383, May 1954. Describes apparatus and method.
144. "The Scientific Film Association Conference — Hastings, 4th–6th April: Some Applications of Technical Cinematography," *Brit. J. Phot., 99:* 245–256, May 23, 1952. Describes a number of technical applications and gives a historical survey.
145. "Underwater Television," *Research, 5:* 201, May 1952. Describes a demonstration of an underwater television camera.
146. "The Film in Medicine," *Business Screen Mag., 13, No. 6:* 27–29, Sept. 28, 1952. Reviews history of films in the medical field; discusses types now in common use.
147. "Three-Dimensional Medical Film Used for Conference," *Film World, 8:* 704, Dec. 1952. Describes first three-dimensional medical film in color shown at British Medical Association.

XVI. STEREOSCOPY

148. Atorf, H., "Three-Dimensional Film in the Light of Patent Literature," *Kino-Technik, 7:* 162–163, June 1953.
149. Biroc, J., "Hollywood Launches 3-D Film Production," *Am. Cinemat., 33:* 336–337, 350–352, Aug. 1952; L. Hochman, "Hollywood's Answer to TV?" *Photography (Chicago), 31, No. 6:* 36–39, 123–124, Dec. 1952. First article deals mostly with the Natural Vision process.
150. Bowen, A., Moir, J., and Turner, H., "Sound-Film Equipment in the Festival of Britain Telekinema," *Brit. Kinemat., 18:* 142–149, May 1951. Extensive details given of projection equipment for stereoscopic system and stereophonic sound system.
151. Cohen, N., "Single-Film, Single Projection 3-D," *Am. Cinemat., 34:* 319, 352, July 1953; "The Schenstad 3-D System, *Brit. J. Phot., 100:* 674, Dec. 25, 1953. A color stereoscopic motion-picture system uses a color wheel and a beam-splitting disk.
152. Cricks, R. H., "First Telekinema Program," *Ideal Kinema* (Suppl. to *Kinemat. Weekly*), *17, 189:* 11, May 17, 1951. Describes stereoscopic and stereophonic films in the Telekinema.
153. Gavin, A., "2-D, 3-D, Wide-Screen, or All Three. . .," *Am. Cinemat., 34:* 210–212, 232–234, May 1953.
154. Gunzberg, J., "The Story of Natural Vision," *Am. Cinemat., 34:* 534–535, 554–556, Nov. 1953; *34:* 590, 612–616, Dec. 1953. Describes technique of making motion pictures with the Natural Vision camera.
155. Jemma, A., "Progress and Future of Stereoscopic Motion Pictures," *Ferrania, 2:* 28–30, Dec. 1948. A description taken from *Naouka* of improvements in the Berthier-Ives grid system made by Semion Ivanov.
156. Jennings, W. W., and Vanet, P., "New Direct-Vision Stereo-Projection Screen," *Jour. SMPTE, 59:* 22–27, July 1952. Describes a screen which can be used for three-dimensional motion pictures and slides but requires no viewing aids such as polarized glasses.
157. Norling, J. A., "Stereoscopic Motion Pictures" (reprint from *Intern. Projectionist, 26:* 12–14, 28–31, Aug. 1951), *Am. Cinemat., 33:* 66, 78–79, Feb. 1952; *33:* 110, 130–132, Mar. 1952.
158. Norling, J. A., "The Stereoscopic Art," *Jour. SMPTE, 60:* 268–308, Mar. 1953.
159. Roe, A. D., "Stereo Movies Without Spectacles," *Am. Cinemat., 33:* 295, 309, July 1952. L. Dodin, a French engineer, developed a method for projecting stereoscopic films on a selectively reflecting screen composed of a number of individual mirrors.
160. Selle, W., "Bibliography of Stereoscopy," *Z. wiss. Phot., 44, No. 10–12:* 212–222, 1949. 155 references to literature from 1842–1949.
161. Spottiswoode, R., "Progress in 3-Dimensional Films in England," *Brit. J. Phot., 99:* 211–212, May 2, 1952. Reviews development of Telecinema and its success.
162. Spottiswoode, R., Spottiswoode, N. L., and Smith, C., "Basic Principles of Three-Dimensional Film," *Jour. SMPTE, 59:* 249–286, Oct. 1952. Discusses basic theory, a practical example, a review of camera procedures and differences in techniques between the flat film and the stereoscopic film.
163. [Waller, F.], "Three-Dimensional Film Claimed," *Mot. Pic. Herald, 179:* 14, Apr. 29, 1950. Cinerama, said to be an extension of training devices developed for gunnery practice during World War II, is described.
164. Weinberg, S. A., Watson, J. S., Gramiak, R., and Ramsey, G. H., "Stereo X-Ray Motion Pictures," *Jour. SMPTE, 62:* 377–383, May 1954. Describes apparatus and method.
165. Wright, E. H., "Stereoscopic Motion-Picture Systems," *Brit. Kinemat., 14:* 137–148, May 1949. Describes the search for a practical stereoscopic motion-picture system.
166. "Three-Dimensional Medical Film Used for Conference," *Film World, 8:* 704, Dec. 1952. Describes first three-dimensional medical film in color shown at British Medical Association.

XVII. TELEVISION

167. Abramson, A., "Short History of Television Recording," *Jour. SMPTE, 64:* 72–76, Feb. 1955. Describes development of the three basic television recording processes since 1927.
168. Coates, W., "Planning the Festival of Britain Telekinema," *Brit. Kinemat., 18:* 108–119, Apr. 1951. Materials and equipment for large-screen television.
169. Cricks, R. H., "Televised Pictures on Large Screen," *Ideal Kinema* (Suppl. to *Kinemat. Weekly*), *17, 189:* 9, May 17, 1951. Describes television equipment used in the Telekinema at the Festival of Britain. First program described.
170. Debrie, A., "An Intermediate Film System for Large-Screen Television Projection," *Tech. cinématographique, 23, No. 109:* 109–112, Apr. 1951. Describes equipment designed for theater use.
171. Dorté, P. H., "Film in Television," *Phot. J., 92A:* 234–239, Sept. 1952. Describes uses to which film is put by BBC Television Service.
172. Fink, D. G., "Constructing the Tricolor Picture Tube," *Electronics, 24:* 86–88, May 1951. Detailed description of the three-gun tricolor picture television tube and its manufacture.
173. Fraser, R. M., "Motion-Picture Photography of Television Images," *RCA Rev., 9:* 202–217, June 1948. Describes recording television programs for documentary, historical, legal, critical, etc., purposes.
174. Garman, R. L., and Lee, R. W., "A Comprehensive Proposal for a Closed-Loop Theater Television System," *Jour. SMPTE, 56:* 473–486, May 1951.
175. Goldmark, P. C., Christensen, J. W., and Reeves, J. J., "Color Television — USA Standard," *Proc. IRE, 39:* 1288–1313, Oct. 1951; *Jour. SMPTE, 57:* 336–381, Oct. 1951.
176. Hickman, R. B., "American Television Film-Recording Equipment," *J. Television Soc., 6:* 167–169, Oct./Dec. 1950. Describes RCA Kinephoto equipment used for recording television programs directly on 16mm film.
177. Jensen, A. G., "The Evolution of Modern Television (1930–1954)," *Jour. SMPTE, 63:* 174–188, Nov. 1954. An account of major developments leading to modern television equipment.
178. Hogan, J. V. L., "The Early Days of Television (1875–1930)," *Jour. SMPTE, 63:* 169–173, Nov. 1954. Traces significant steps.
179. Keane, N., "Films for Television," *Am. Cinemat., 30:* 125, 138–140, Apr. 1944. Reviews difficulties encountered when motion-picture feature films are used for TV programs and suggests improvements for such films if they are to be used widely.

180. Sandvik, O., and Veal, T. G., "Motion-Picture Films for Television," *Brit. Kinemat., 17, No. 5:* 141–158, Nov. 1950. A.G.D. West Memorial Lecture.

181. Sims, J. W., "Two Types of Theatre Video," *Audio Eng., 36:* 16–17, 38–39, Jan. 1952. Describes GPL Videofilm System and another less expensive direct-projection system.

182. Smith-Rose, R. L., "Progress in Colour Television," *Nature, 169:* 563–566, Apr. 5, 1952. A survey.

183. Stutz, T., "New Method of Television Scanning of Films," *Tech. Mitt. PTT, 32:* 1–27, 1954; *Phot. Abstracts, 35:* 44, 1955. Survey of systems of television film scanning.

184. Wintringham, W. T., "Color Television and Colorimetry," *Proc. IRE, 39:* 1135–1172, Oct. 1951. History of color measurement is reviewed; principles of modern three-color colorimetry and application of colorimetry to color TV are discussed.

185. "Britain First With 625 Lines, Large-Screen Television," *Kinemat. Weekly, 391:* 28, Sept. 8, 1949. Describes a demonstration given before the International Television Convention and Exhibition in Milan, using a projected picture 12 by 16 ft.

186. "Underwater Television," *Research, 5:* 201, May 1952. Describes a demonstration of an underwater TV camera.

187. "Fox Unveils Eidophor," *Intern. Projectionist, 27:* 14, 17, 30, July 1952; *Intern. Phot., 24:* 5–6, Sept. 1952; Coulter, L., "The Unveiling of Eidophor," *Ideal Kinema* (Suppl. to *Kinemat. Weekly*), *18, No. 203:* 9, 22, July 10, 1952. (cf. *Film World, 8:* 418, Aug. 1952). Describes underlying principles, optics, prisms, color mechanism, equipment and results obtained by the Eidophor system of theater TV in color.

188. "RCA Color Theater TV Impressive in Trial," *Mot. Pict. Herald, 185, No. 3:* 17, Oct. 20, 1951. Color TV on a screen 9 by 12 ft.

XVIII. THEATERS, MOTION-PICTURE

189. Underhill, C. R., Jr., "The Trend in Drive-In Theaters," *Jour. SMPTE, 54:* 161–170, Feb. 1950. Traces development, gives design features and projection needs of a drive-in theater.

190. "An 'Ideal Theatre' is Planned for Williamsburg," *Intern. Projectionist, 30:* 25, 40–41, Dec. 1955. Describes unique twin theatre to be built in historic Williamsburg, Virginia. (Completed and opened — Spring 1957.)

191. "Exhibition Is 60 Years Old," *Kinemat. Weekly, 469:* 21–92, May 3, 1956.

XIX. WIDE-SCREEN PROCESSES

192. Benford, J. R., "The CinemaScope Optical System," *Jour. SMPTE, 62:* 64–70, Jan. 1954. Describes optical and sound and related factors of CinemaScope.

193. Boyle, J. W., "And Now — Cinerama," *Am. Cinemat., 33:* 480–481, 498–500, Nov. 1952. Describes the Cinerama process and its possibilities.

194. Chrétien, H., "Panoramic Motion Pictures by the Hypergonar," *Bull. assoc. franc. des ingénieurs et techniciens du cinéma, 6, No. 11:* 13–23, 1952. Describes design and use of anamorphic lenses for taking and projection of motion pictures.

195. Cook, G. H., "Recent Developments in Anamorphotic Systems," *Brit. Kinemat., 26:* 61–71, Mar. 1955.

196. Daily, C. R., "New Paramount Lightweight Horizontal-Movement VistaVision Camera," *Jour. SMPTE, 65:* 279–281, May 1956. Describes a portable camera for use on locations to film Vista-Vision features; it weights 17½ lb and accommodates a 400-ft reel of film.

197. Gavin, A. E., "Tomorrow's Wide-Screen Camera. . .," *Am. Cinemat., 35:* 174–176, 202–204, Apr. 1954. Discusses the program of Paramount Pictures Corp. to develop an efficient VistaVision camera.

198. Gavin, A. E., "CinemaScope on 55 Film," *Am. Cinemat., 36:* 582–583, 610, Oct. 1955. Describes a wide-screen system developed by Twentieth Century-Fox Films Corp.

199. Greene, W. R., "New CinemaScope '55'," *Intern. Phot., 28:* 5–6, Mar. 1956.

200. Greene, W. R., "Two New Wide Screen Processes," *Intern. Phot., 28:* 8, June 1956. Describes the Delrama anamorphic system and the Scope 17 anamorphic lens that may be used either with camera or projector.

201. Kotte, J. J., "Cinema Projector for 70-mm and 35-mm Films," *Philips Tech. Rev., 17:* 299–302, Apr. 1956. Describes the Philips Projector EL 4000, manufactured specially for the Todd-AO system.

202. Rowan, A., "Cinepanoramic — New French Anamorphic Lens," *Am. Cinemat., 34:* 434, 442–445, Sept. 1953. A lens similar to CinemaScope produces 2.50 : 1 image compressed in standard 35mm frame.

203. Rowan, A., "Todd-AO — Newest Wide-Screen System," *Am. Cinemat., 35:* 494–496, 526, Oct. 1954. A system for wide screen, using a camera with wide-angle lens, and 65mm negative, developed by the American Optical Co. and Michael Todd; negative and prints are on Eastman Color films; system employs a single camera and a single projector, giving an image with a 2 : 1 aspect ratio on a curved screen having a high-reflectance surface.

204. Spottiswoode, R. J., "2-D and 3-D Trends in the Current Cinema," *Brit. Kinemat., 23, No. 5:* 124–136, Nov. 1953. Discusses development of wide screen and stereoscopy.

205. [Waller, F.], "Three-Dimensional Film Claimed," *Mot. Pict. Herald, 179:* 14, April 29, 1950. Cinerama, said to be an extension of training devices developed for gunnery practice during World War II, is described.

206. "Summary of Current Wide-Screen Systems of Photography," *Am. Cinemat., 36:* 654–656, 674–676, Nov. 1955. Describes Cinerama, CinemaScope, VistaVision, Todd-AO, T.F.C.- 4×-55mm, and Superscope processes; shows pictures of cameras and sample film strips for each process.

207. "The Trend to Wider Motion Picture Negatives," *Am. Cinemat., 36:* 332–333, 368, June 1955. A summary of processes being used and investigated.

208. "Technicolor Offers 'Technirama,' a New System of Large-Screen Projection," *Mot. Pict. Herald, 207, No. 12:* 27, Sept. 22, 1956. Describes a large-screen projection system. The film moves through the camera horizontally, exposing pictures having eight perforations per frame.

209. "This is Cinerama on Broadway," *Mot. Pict. Herald (Better Theaters Sect.)*, pp. 14–15, 41–42, 44, Oct. 11, 1952. Cinerama process is described.

210. "CinemaScope — What It Is; How It Works," *Am. Cinemat., 34:* 112–113, 131–134, Mar. 1953.

211. "CinemaScope and How It Works," *Cine-Technician, 19: No. 102,* 58–60, May-June 1953. Describes processes and work of Chrétien.

news and reports

Papers Program for the 85th Convention, May 4–8, 1959, Fontainebleau Hotel, Miami Beach

Theme: *Films and Television for International Communication.*

85th Convention Program Chairman: **Garland C. Misener,** 1905 Fairview Ave., N.E., Washington 2, D.C.

85th Convention Assoc. Program Chairman: **C. Henderson Beal,** 9781 S.W. 60 Ct., South Miami, Fla.

TOPICS AND TOPIC CHAIRMEN

Audio Visual Communications: **Dr. Sydney W. Head,** Radio-TV-Film Dept., Univ. of Miami, P.O. Box 8106, Coral Gables 46, Fla.

Cinematography: **Dr. John Storr,** Univ. of Miami, Marine Lab., No. 1 Rickenbacker Causeway, Miami 49, Fla.

High-Speed and Instrumentation Photography: **Lincoln L. Endelman,** 474 Naish Ave., Cocoa Beach, Fla.; *Asst. Chairman:* **Gaver M. Powers,** 1385 Orange Blossom, Eau Gallie, Fla.

Laboratory Practice: **Harold Jones,** Professional Motion Picture Dept., Ansco, Binghamton, N.Y.

Multilingual Films: **Max G. Kosarin,** Service Div., Army Pictorial Center, Long Island City 1, N.Y.

Sound Recording and Reproduction: **Boyce Nemec,** Reevesound Inc., 35–54 36th St., Long Island City 6, N.Y.

Standards and Standardization: **Philip M. Cowett,** Box 227M, Rt. 5, Vienna, Va.

Studio Lighting and Practices: **George H. Gill,** Century Lighting Inc., Box 775, North Miami, Fla.

Television: Broadcast and International Facilities: **Glenn H. Dorsey,** 17 N.W. 3rd St., Miami, Fla.

Television: Film Techniques: **M. Peter Keane,** Screen Gems Inc., 711 Fifth Ave., New York 22, N. Y.

Television: Recording: **John L. Koushouris,** CBS Television, 485 Madison Ave., New York 22, N. Y.

Theaters and Projection: **Willy Borberg,** General Precision Laboratory, Pleasantville, N.Y.

Deadline: February 16, 1959. (This means that all Author Forms MUST be in the hands of the Program Chairman on or before this date. After the deadline has passed, papers can be accepted for presentation at the Convention ONLY by special arrangement by the Program Chairman or by the Papers Committee.)

Note to Authors: The deadline, noted above, means of course, that it is the responsibility of the Author to make sure that the Author Forms are submitted to the Topic Chairman far enough ahead of the deadline so that no undue burden is added to the responsibilities of those who make the program. The earlier the better!

Although many, and perhaps most, of the papers presented at the Convention are later published in the *Journal*, acceptance of a paper for presentation at the Convention does not, per se, mean that the paper is also accepted for *Journal* publication. Before a manuscript is accepted for publication in the *Journal*, it is reviewed by the Board of Editors. A paper suitable for oral presentation would not necessarily be suitable for publication. Demonstrations would usually fall into this classification, although they might be reported in the *Journal*. In respect to the subject matter of a paper, it can occur (and usually does) that an excellent manuscript does not, apparently, fit into any set category. (Reminding one of the famous drama, *Six Manuscripts in Search of a Topic Chairman.*) These temporarily homeless manuscripts should be sent to the Program Chairman, or the Assoc. Program Chairman, who will decide on the Topic or Session to which they may best be related.

General Comment: The theme of the 85th Convention relates the special interests of the Society and its members to the wider concept of communication and thus to the vital and immediate concerns of thinking people throughout the world, and it serves to emphasize the significant contributions that have been and are being made.

In relating the interests of the Society to world-wide concerns it is relevant to note that the geographical areas represented by the members of the Society are becoming more extensive. Areas represented by Regional Papers Chairmen, other than the United States and Canada, include (in Asia) India, Japan and the Philippines; (in Australasia) Australia and New Zealand; (in Europe) Denmark, France, Germany, Great Britain, Italy, The Netherlands, Sweden and Switzerland; and (in the Western Hemisphere) Argentina, Brazil, Colombia, Mexico and Venezuela.

The relationship within the Society of members from various regions throughout the world becomes especially meaningful in the contributing of the community and diversity of points of view that have so much to do with the success of a Convention.

Conventions do not spring into being overnight and the success of a Convention is not based on last-minute inspiration but rather on dedicated, behind-the-scenes work. Some of the story is told in the Directory for Members (April Pt. II, 1958) which lists the Chairmen of the standing Papers Committee. A great deal of effort is necessary if the Convention is to meet, and perhaps surpass, standards of success set by previous Conventions. Due to the efforts of Papers Committee Chairman Ben Plakun working in close cooperation with Editorial Vice-President Glenn Matthews, a great deal of planning and preparatory work has already been possible on the part of your 85th Convention Program Chairman.

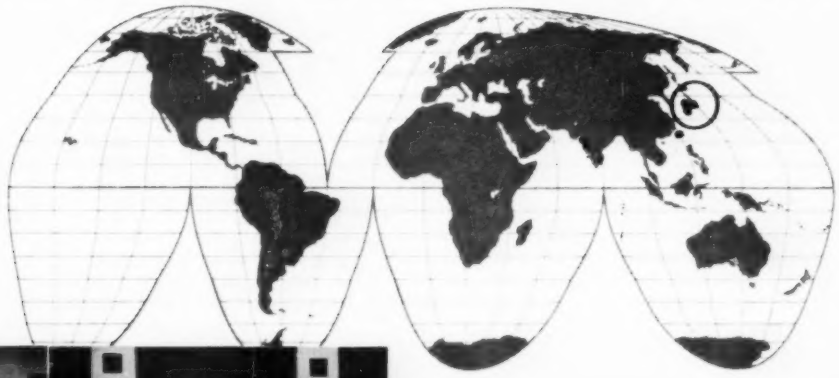
Suggestions about papers or paper prospects can be submitted to the Program Chairman, or the Associate Chairman, or to the Editor at Society Headquarters.—*Garland C. Misener*, 85th Program Chairman.

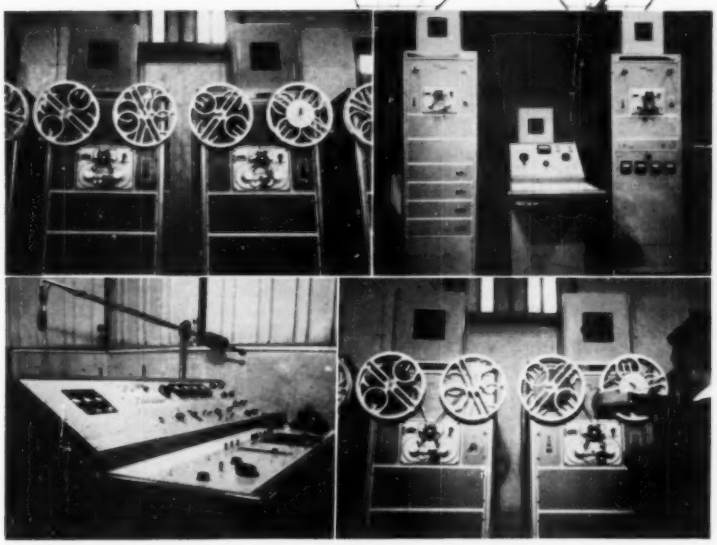
Equipment Exhibit

According to present planning, the world-wide scope of communications that is the general theme of the papers program for the Miami Convention will be reflected in the choice of new equipment to be shown in the Exhibit. This will take on an international character with displays invited from manufacturers in several European countries as well as from other parts of this hemisphere. It is also expected that the proximity of so much missile instrumentation activity in Florida will attract a sizable concentration of high-speed photographic and data instrumentation equipment.

The Exhibit Chairman for this occasion will be John B. Olsson, c/o Beattie-Coleman, Inc., 1000 N. Olive, Anaheim, Calif. Detailed information about available space will be going out to past and potential exhibitors very soon; in the meantime, any companies who want to be sure of receiving information and order forms should get in touch with John Olsson or notify Denis Courtney at Society headquarters.

AROUND THE WORLD WITH MAGNASYNC





tokyo (Japan)

The prosperous, expanding Japanese motion picture industry is finding in Magnasync the perfect solution to systematic growth. The montage at the left shows part of the complete systems installation in K.R.C. Studios, Tokyo. Complete with mixing consoles, 35 mm recorders, dubbers and electrical interlocks, this well planned system can be easily expanded to keep pace with the growth of K.R.C. Studios.

Other Magnasync "sound-system" installations in Japan include the Fuji Television Studio, Tokyo, Radio Tokyo Studio, Tokyo, Kansai Television Studio, Osaka, and Chubu Nihon Broadcasting Corporation, Nagoya.

This first class studio selected the popular Magnasync 135 series 35 mm film transports.

The single channel, triple channel and CinemaScope release print amplifiers are packaged with the transports in neat uniform cabinets—giving the installation that "planned-by-Magnasync" look.

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Photography's Place in Space

Speaking on the theme of "Photography and the Search for Knowledge" at the Annual Banquet of the Society of Photographic Scientists and Engineers, Oct. 9, in Rochester, N.Y., Donald McMaster, Vice-President and General Manager of Eastman Kodak Co., took his "man with a camera" out toward Mars and back to the Earth, and showed him photographically recording information "in a way to stagger the imagination."

Among his predictions, based on present accomplishments of photography: "As of today, the output of electronic computers can be recorded by photography at the rate of 100,000 characters a second. We foresee a rate of one million characters a second in the near future."

In his discussion on computers — among many photographic applications — Mr. McMaster told of a computer which is being programmed to translate Russian into English. "The information it must have to do this," he said, "is provided on a 12-in. disk where 60 million discrete bits of information have been transcribed by photography. . .and only part of the surface of the disk is used."

In discussing possible future developments, he mentioned recent advances in the resolving power of films. He pointed out that there are, at the present time, films available which can clearly resolve 2000 lines/mm, at low sensitivity levels, "a capacity which. . .exceeds that of present day optics." He predicted that better lenses would be designed which will match the potentialities of these films.

In his talk Mr. McMaster spoke at some length of the challenge of space technology. In a reference to rockets around the Moon, he suggested that a rocket carrying automatic cameras with telephoto lens and automatic processing equipment, linked to a TV system to scan the finished film and transmit the image to Earth would give man his first glimpse of the "dark side" of the Moon. "When man himself eventually goes out into space, it's a dead certainty that he'll take his cameras with him," he said.

He told the assembled photographers that it might be their destiny to open up whole new areas of knowledge and that the development of present programs may make possible the gathering of information "which is beyond all present comprehension."

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Education, Industry News

Two especially impressive exhibits were seen at the Western Electronic Show and Convention held in the Pan Pacific Auditorium and Ambassador Hotel, Los Angeles, Aug. 19–22. The Historical Exhibit suggested a journey back into the past of only a little more than 50 years ago, while the Future Engineers Show, which displayed the work of high-school students, afforded a rather startling glimpse into the very near future.

Replicas of early vacuum tubes, lent by Lee de Forest, a 1912 radio license, a shipboard radio receiver (circa 1916) and other early equipments and documents suggested the beginnings of a different world and a different kind of auditory and visual communication. Over in the Future Engineers Exhibit, high-school students demonstrated and described such projects as "Radio Controlled Robot," "Determination of E," "Satellite Model," "Cybernetics," "Ionic Loudspeaker," and others — 33 in all — equally indicative of the strange ways to be traveled in the next 50 years.

New research areas in speech and television are foreseen by using general purpose digital computers in the simulation of new coding and transmission devices, according to scientists at Bell Telephone Laboratories, who reported most recently at the Western Electronics Conference in Los Angeles. Earlier, in July 1957, R. E. Graham presented a paper on "Communication Theory in Television Coding" before the UNESCO-sponsored International Symposium on Physical Problems of Color Television, held in Paris. He described techniques of picture coding research based on computer simulation. Highlights of the Paris Symposium of special interest to the Society were reviewed by Mr. Graham at the SMPTE 1957 Fall Convention in Philadelphia.

In using computer simulation to evaluate proposed television coding schemes and to

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The new 1000 ft. Blimp converts the ARRIFLEX 35 into a full-fledged SOUND STUDIO CAMERA, and brings further versatility to the ARRIFLEX 35 system. It accepts the ARRIFLEX 35 with regular synchronous motor, and utilizes standard Mitchell magazines, which are joined to the camera by means of an adapter, supplied with the Blimp. No alterations are necessary on the ARRIFLEX 35 or the Mitchell Magazine. No tools are needed. It takes but a few minutes to change the ARRIFLEX 35 from hand camera to studio camera or vice versa.

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Wired for buckle switch which can be built into existing cameras and is factory supplied with camera if bought with Blimp.
ARRI-Precision Engineered for a lifetime of trouble-free service.

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improve others, an input picture of 100 × 100 elements, corresponding to an area about 1/25 that of a conventional TV frame, is used to hold machine time and memory requirements to a reasonable level. For typical coding schemes, the total computer time required is 5 sec to 10 sec per picture. A magnetic tape recording of the video signal is prepared by scanning a square picture with 100 scanning lines in 2.4 sec. Each picture dot is quantized to 10-bit accuracy, providing 1024 amplitude levels and is recorded in 7 parallel tracks with 200 characters to an inch of tape. The tapes are then fed into the computer where they are processed according to a preassigned program. The resulting signal is rooted, mixed with a synchronizing waveform in the conventional manner, and band limited to 2500 cycles/sec. In playback, the computed picture signal is converted back to analog form. It is then passed through a low-pass filter, and displayed on a monitor with two kinescope tubes. One of these tubes has a slow phosphor for direct viewing, while the other has a fast phosphor for photography.

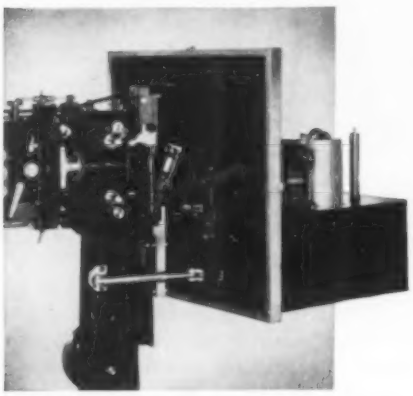
A coding scheme relevant to TV transmission, called "Predictive Quantizing," has been studied by simulation and by conventional methods. This scheme takes advantage of the relatively low level of viewer perception during periods of scene change or motion, and in areas of picture confusion, these being the only regions in which predictive coding systems make significant errors. The method involves quantizing the difference between the original continuous signal and a predicted version of that signal. It employs fine quantum steps for small errors and coarse steps for large errors, where the predictor and the viewer are surprised. This tapering of steps in the quantizing staircase allows the use of a smaller number of total levels, and thus reduces the channel capacity requirements.

A limiting case of predictive quantizing, in which the predictor is simply a one-sample delay, has been tested with simulation equipment and with standard 525-line television, and found to afford a picture not significantly degraded from the original, and requiring only three bits per picture dot.

Computer simulation has provided a method for the investigation of a number of variations of predictive quantizing. Its use in picture analysis for pattern recognition and for statistical computations is being studied.

R. E. Graham, Bell Telephone Laboratories, prepares to photograph a reproduction of a TV picture following processing by computer simulation, while E. E. David, also of Bell Laboratories, adjusts the monitor controls.

Dr. James R. Killian, special assistant to the President for science and technology, addressing the Annual Meeting of the Land Grant Colleges and State Universities in Washington, D.C., November 11, said that college science teachers should abandon "high-hat attitudes about movies and TV" and learn to use these media to train future scientists. Research on new teaching aids is important, he said, because "in the immediate years ahead the rising number of students will outrun the supply of college teachers." The flow of new graduates into teaching in the next few years will be less than a quarter of the number needed; to compensate, educators must find ways to use these tools to bring the teacher into effective touch with greatly increased numbers of students.



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Supplied to fit existing machines of Depue-Carlson and Andre Debrie Step Printers and Bell & Howell Continuous Printer Models D & J.

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This 3-light additive color unit supplies discrete blue, green and red beams. No one beam contributes to contamination of the others.

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High efficiency interference-type dichroic beam splitters to form a single mixed output beam.

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Adjustable lamp sockets to line up filaments. Three degrees of freedom; vertical, rotational, lateral.

Four-leaf adjustable diaphragm, imaged at the printing aperture which provides an optical printing aperture for exposure and/or uniformity control.

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3-Channel Memory Unit with Reader for automatic operation of flipper assembly, reading in succession blue, green, red and storing the introduced information. 15 neon pilot lights indicate when the 15 neutral density filters are in or out so that operator can see at a glance if Reader and Memory Unit are functioning properly. For easy servicing, commercially available punched tape reader is used as a base. Price: $3,200 F.O.B. New Rochelle, N. Y.

Keyboard and Punch with 32 combinations for each color; blue, green, red; with an additional channel for introducing other information such as stop, lap dissolves, etc., and with built-in scene counter. Can also be used with Reader to reproduce automatically duplicate tapes and will permit corrections of the tape and continue with the accepted information.

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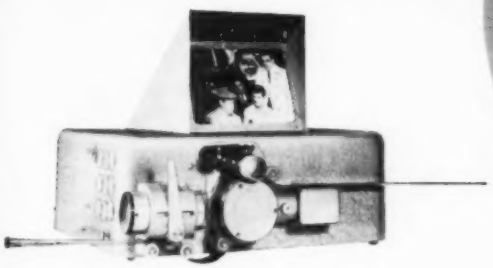

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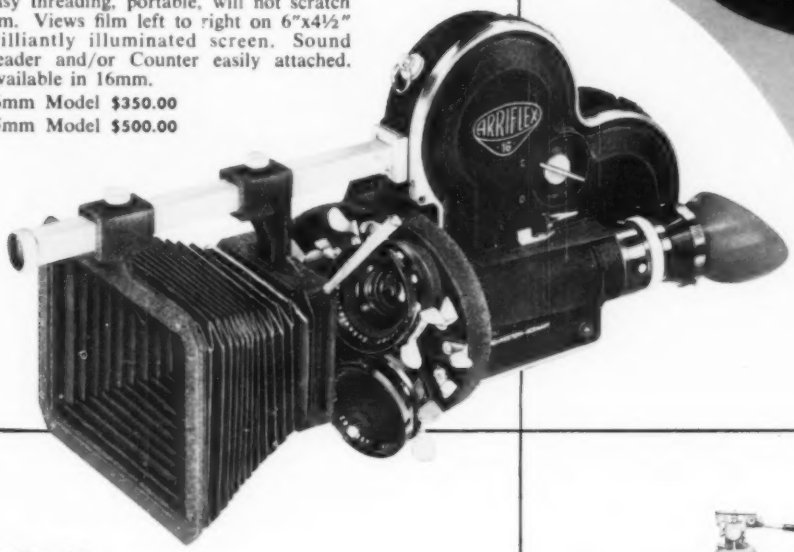

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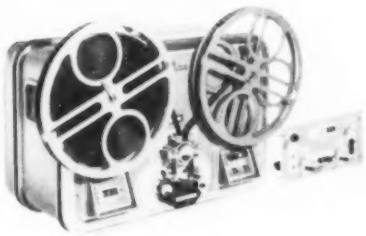

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The worlds of theater and classroom, once widely separated by custom and tradition, are moving closer together as teachers and professors are required to learn a few acting techniques and basic "tricks of the trade" as part of their teaching equipment. Teachers of TV courses at New York Univ. and others selected for the Channel 11 project in elementary and high-school courses are instructed by TV personnel at the University Studio, 51 W. 4 St., New York. One of the first things TV teachers are taught is to write legibly on the blackboard, bearing in mind the limitations of the camera's eye, so that words and equations do not appear to be sprawling off into outer space.

The Institution of Telecommunication Engineers will hold its Second Technical Convention Dec. 27–28, 1958, in New Delhi. Papers scheduled for presentation before the Convention will be on such subjects as Antenna and Wave Propagation; Broadcasting in India; Tropicalization of Communication Equipment in India; Semiconductors; Telephone Communication in India; Navigational Aids; and Atmospheric and Radio Noise.

The 14th Annual National Electronics Conference held in Chicago, Oct. 13–15, contained about 100 papers. Highlights of the program included a panel discussion on "The Role of the Laboratory Program in Engineering Education," a session on "Engineering Writing and Speech," a report on satellites and space stations and a discussion of automatic navigation. There were such topics as antennas, audio, communications, computers, engineering management, industrial electronics, instrumentation, amplifiers, microwaves, radar and radio navigation, television and transistors. The Conference was sponsored by American Institute of Electrical Engineers, Illinois Institute of Technology, Institute of Radio Engineers, the University of Illinois and Northwestern University. Participants were the SMPTE; Electronics Industries Assn.; and the Universities of Michigan, Michigan State, Notre Dame, Purdue, Wayne State and Wisconsin.

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Irritate Audiences

Scratches are havens for dirt, and refract light improperly. On the screen, they mar the picture and may distract attention. If on the sound track, they produce offensive crackling.

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Three photographic scientists were honored at the Annual Banquet of the Society of Photographic Scientists and Engineers, held Oct. 9 in Rochester, N.Y. Louis Philippe Clerc, venerable French photographic scientist and teacher, and editor for more than 30 years of *Science et Industries Photographiques*, was granted the highest honor bestowed by the SPSE, that of honorary membership. Cyril J. Staud, Vice-President in charge of research at Eastman Kodak Co., and Edward K. Kaprelian, associated with the direction of research and development at the U.S. Army Signal Research and Development Laboratories, were made Fellows of the SPSE. They were cited for "outstanding service in the advancement of photography."

A special award of senior membership status was made to Edward S. Cobb, Managing Secretary of SPSE, in recognition of major service to the organization.

Dr. Staud, who is a Fellow of the SMPTE, is the author of papers in the fields of general color, photography and industrial research. Mr. Kaprelian, a Past-President of the Society of Photographic Engineers, has been recognized for distinguished service to the government in the field of photographic science.

An International Convention on Transistors and Associated Semiconductor Devices will be held May 25–29, 1959, under the auspices of the Radio and Telecommunication Section of the Institution of Electrical Engineers, Savoy Place, London W.C.2. The Convention will review the ten years that have passed since the invention of the transistor in terms of the significance of its development, the extensive engineering that has resulted from it and its long-range potentialities. An Exhibition, held in connection with the Convention, will cover all aspects of transistors and semiconductor devices. Early plans include lectures by internationally known scientists and presentation of papers by specialists in the field from European countries, Russia and the United States.

Alfred N. Goldsmith, consulting engineer in the electronics and motion-picture fields, has been elected to the Board of Directors of RCA Communications Inc. Dr. Goldsmith joined RCA in 1919 as Director of Research and later was appointed Vice-President and General Engineer. Since 1931 he has served as a technical consultant to RCA. A Past-President of this Society, he was awarded the Progress Medal in 1956. Other honors include the IRE Medal of Honor and the Founders Award, and the Modern Pioneers Award. He has also served as

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Standard of the professional recording industry, it consistently delivers the finest in audio reproduction. Available in as many as 8 channels, in console and rack mounting.

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First choice of the broadcasting industry. Features printed circuits and miniature tubes. Available in console, rack and portable models, with one or two channels. Sold by dealers.

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President of the IRE. Organizations in which he holds the rank of Fellow, besides the SMPTE, include the AIEE, the IRE, American Physical Society, American Assn. for the Advancement of Science, Optical Society of America, and the International College of Surgeons.

Solita Palmer has been engaged to write the original music for the film *Statehood*, now in production for the U.S. Information Agency, Washington, D.C., for multilingual overseas distribution. Miss Palmer is a member of ASCAP and AGAC (American Guild of Authors and Composers). Producer of the film is Emerson Yorke. Mr. Yorke, a Fellow of the Society, is an independent producer.

Louis L. Behrmann has been appointed Director of Technical Sales for Unicorn Engineering Corp., a subsidiary of Pacific Industries Inc. Prior to his present appointment, he was Chief of the Motion-Picture and Kine Recording Section of Walter Reed Army Hospital. His work there included development of color kinescope recording equipment and the establishment of a color TV system. In his present post he will maintain liaison between the company and users of automated printers and other motion-picture equipment manufactured by the firm.

CBS Laboratories, a division of Columbia Broadcasting System, Inc., opened its new Research Center in Stamford, Conn., on October 7. Situated on a 23-acre site, the glass-enclosed building is constructed of aluminum and steel. The laboratories contain facilities for research and development in such fields as audio-video systems, solid state physics, physical chemistry, optics, vacuum tubes, data processing systems and electronics for communications and other applications.

SMPTE Elections

Names of the new SMPTE officers were announced at the 84th Convention. Officers elected for the two-year terms beginning January 1, 1959, are: Norwood L. Simmons, President; John W. Servies, Executive Vice-President; and Reid H. Ray, Convention Vice-President. The last two elections left vacant the offices of Financial Vice-President and Treasurer. These offices were later filled by appointment. G. Carleton Hunt was appointed Financial Vice-President for 1959; and S. P. Solow was appointed Treasurer. Glenn E. Matthews was re-elected Editorial Vice-President; and Wilton R. Holm was re-elected Secretary. The terms of Engineering Vice-President Axel G. Jensen and of Sections Vice-President Ethan M. Stifle expire in 1959.

The six Governors elected or re-elected for the 1959-1960 term are: Gerald G. Graham, Theodore B. Grenier, Ub Iwerks, Kenneth M. Mason, Robert C. Rheineck and James L. Wassell. The Section Chairmen-Governors for 1959 are: James C. Diebold, Chicago; and Robert G. Hufford, Hollywood. The slate of Governors is short one member for 1959 because of the election of the Chairman of the New York Section (Mr. Rheineck) to the Board of Governors for the 1959-1960 term. The Chairman of this section is automatically a Governor for the term of his office as Chairman.

The Section Chairmen, Secretary-Treasurers, and Managers elected or re-elected for the 1959 term are listed below. Managers elected for the 1958-1959 term were not, of course, candidates in this election. A new section, Nashville, held its first election and the names of officers and managers elected for the one-year and the two-year terms are listed.

Atlanta
Chairman, B. M. Loden; Secretary-Treasurer, Wesley Sandell; Managers, Charles D. Beeland, Jr., Edward E. Burris and William Henry White.

Canada
Chairman, R. J. Beaudry; Secretary-Treasurer, Ronald E. Ringler; Managers, B. James Bach, Findlay J. Quinn and Rodger J. Ross.

Chicago
Chairman, Jerome C. Diebold; Secretary-Treasurer, William H. Smith; Managers, H. Richard Hertel, John H. Maynard and George Meyers.

Dallas-Fort Worth
Chairman, Edward J. Pattist; Secretary-Treasurer, Philip Wygant; Managers, Richard T. Blair, Lewis Cearly, Jr., Bruce Howard and Bruce Jamieson.

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G.B-Kalee is a division of Rank Precision Industries, manufacturing G.B-Kalee sound recording and reproducing equipment, covering every conceivable operational requirement.

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CAMERA LENSES AND ACCESSORIES
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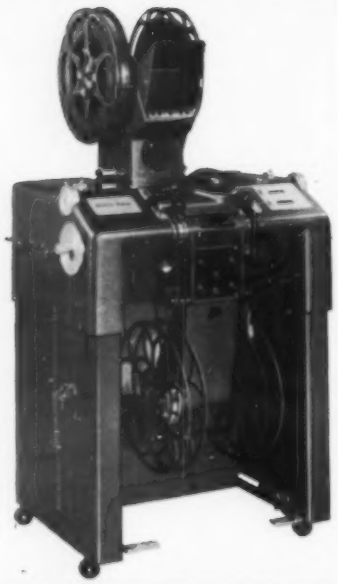

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Biographical Note

Raymond Davis

The retirement of Raymond Davis from the post of Chief of the Photographic Technology Section of Optics and Metrology Div., National Bureau of Standards, has been announced. A native of Washington, D.C., Mr. Davis has been with the Bureau since 1911. Following his retirement, he will serve as consultant to the Optics and Metrology Div.

His duties included direction of the Bureau's photographic research and testing program. Certain of his research projects resulted in three international standards, one of them being the well-known Davis-Gibson series of reproducible light filters. His accomplishments include the development of an improved method of evaluating characteristics of photographic papers and the development of the first camera capable of recording the entire cylindrical surface of a bullet as one continuous picture. He also developed a method of deciphering charred documents. He is the author of articles on the effectiveness of intermittent exposures and on techniques of photoetching divided circles of high precision.

In 1949 he was awarded the Meritorious Service Award for Outstanding Service by the Department of Commerce, and in 1955 he was awarded a fellowship for outstanding achievement in photographic engineering by the Society of Photographic Engineers. In addition to membership in the Society of Photographic Scientists and Engineers, he is a member of the Washington Academy of Sciences, American Chemical Society, Optical Society of America and Philosophical Society of Washington, D.C. He has also served on a number of photographic committees of the American Standards Assn.—*Frank Smith.*

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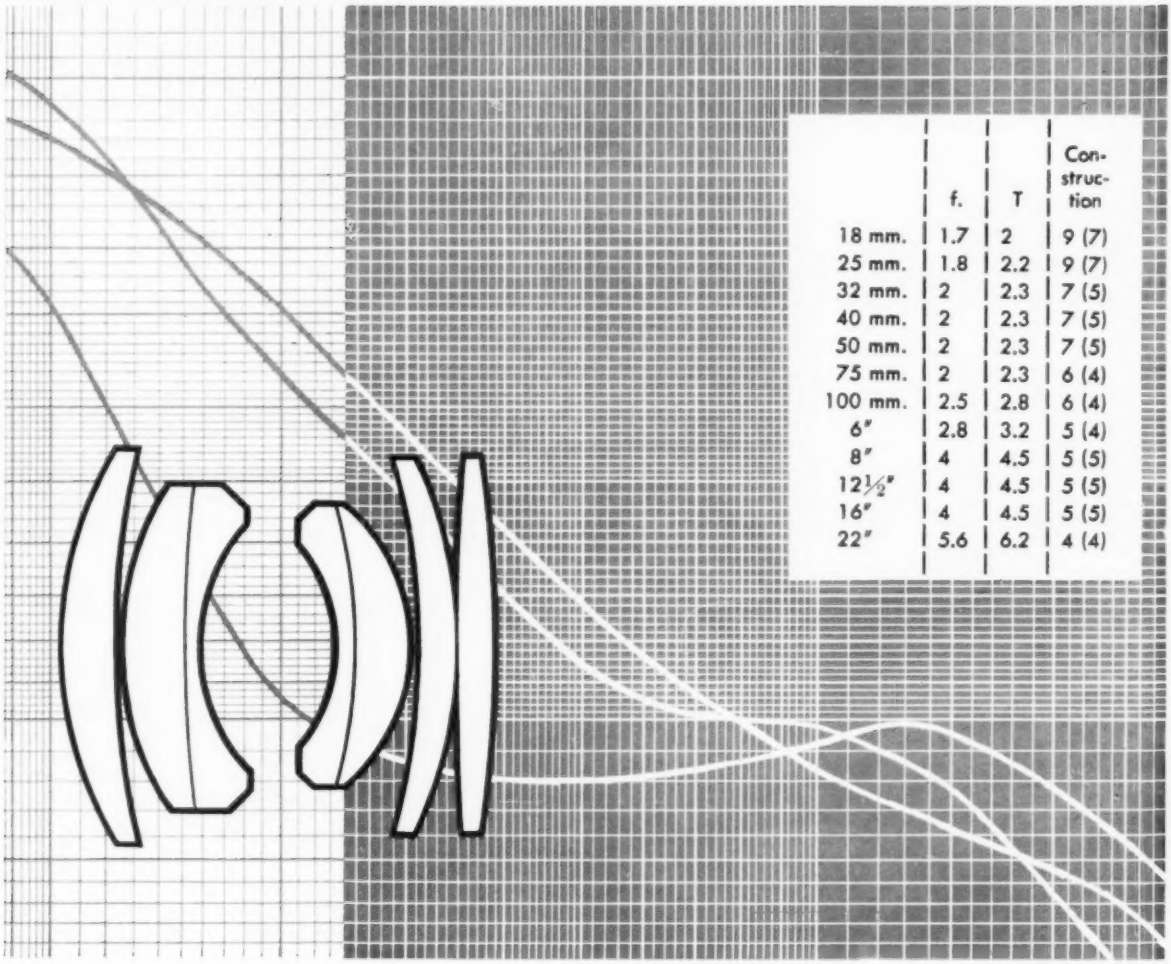

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Obituaries

John W. Butler

John W. Butler, a member of the SMPTE, and one of the pioneers of the motion-picture industry, who helped to guide it over the difficult transition from silent movies to "talkies," died on October 9, 1958, after a short illness. He leaves two daughters and four granddaughters.

Mr. Butler, a native of Newport, R.I., spent most of his boyhood days in Norwood, Mass. He attended schools at Cambridge and Boston, Mass. In 1920 he joined Paramount and served as senior accountant until 1926, when he became assistant to the producer in charge of the New York production office. In 1928 he became Executive Manager of the Paramount Studios in Astoria, organized the production and technical staff, and guided the installation of the first sound equipment there. Many stars made their debut in sound pictures in Astoria during that period—notably Eddie Cantor, Jeanne Eagles, Walter Huston, Edward G. Robinson, Claudette Colbert, and the Marx Brothers.

Mr. Butler left Paramount in 1930, and after various independent activities joined the Army Pictorial Center in 1942, shortly after the Army took over the Paramount Astoria Studios for the production of training films. He served first with the Comptroller Division and later

was successively Chief of Service, Studio, and Production Divisions. From 1955 until his death he was Chief, Operations Advisory Office, on the staff of the Commanding Office.

I shall always be grateful to John Butler for giving me my first job in the motion-picture industry back in 1928 when Paramount was just getting started with its first sound equipment installation in Astoria. He gave me much encouragement in those early years. Later it was my privilege to work under him again under Army auspices. For the past three years when we were closely associated in staff work his wealth of experience in production and administrative problems was a continual source of inspiration and guidance. The motion-picture industry and the Government have lost a faithful and valued leader.—*George Lewin.*

Stephen Szeglin

Stephen Szeglin, a member of the SMPTE for many years, died on September 19, 1958, at the age of 55.

He was born in Hungary but came to this country at an early age and worked for various projector manufacturers and also as a projectionist. He was a member of the IATSE, Local 306.

It was my privilege to work with "Steve" for the past fourteen years at the Army Pictorial Center where he was employed as a sound equipment technician. He was a skilled craftsman — with a wealth of ideas and the enthusiasm to put them into practice. He played an important part in the various projects we undertook to improve technical operations at the Center. He was of great assistance to me in the preparation of the papers describing this work which I prepared for presentation before the SMPTE and publication in the *Journal*.

He will be sorely missed by all of us who were privileged to have been associated with him as fellow-worker and friend.—*George Lewin.*

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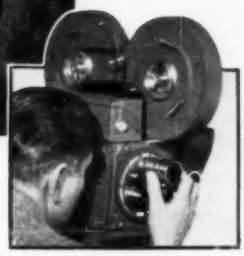

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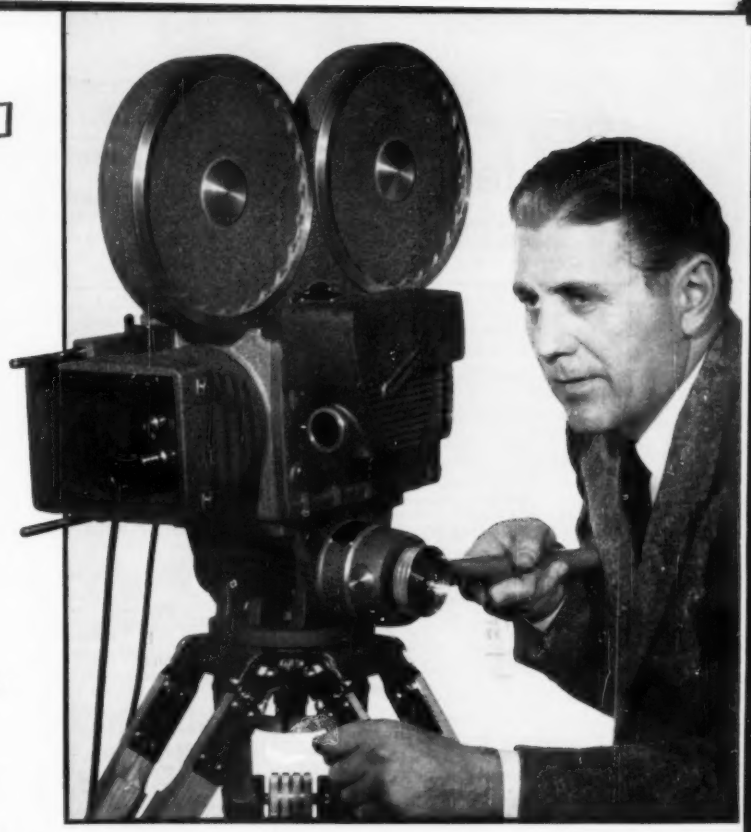

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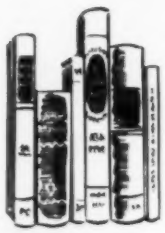

books reviewed

Dictionary of Photography and Motion-Picture Engineering Vol. I: English-German-French

By Wolfgang Grau. Published (1958) by Verlag für Radio-Foto-Kinotechnik G.M.-B.H., Berlin-Borsigwalde, Eichborndamm 141-167, Germany. 644 pp. 6 by 8¼ in. Price DM 37.50.

Because of the special problems of technical translation, and the rapid changes in technical arts as compared with general language, a new specialized technical dictionary is always welcome. In the motion-picture field, a glossary of some 250 entries in five languages was presented by C. C. Santini in this *Journal* in February and October of 1956. The Annuario del Cinema Italiano, 1954–55, contained a glossary of over 2000 words in four languages.

The present dictionary contains 16,000 entries in English, German and French. It is the first of three volumes, and has the terms arranged in alphabetical order in English. In the two volumes to come the alphabetical order will be respectively in German and French.

The author tells in a preface that this book is the outgrowth of a set of personal notes which he has kept nine years on terms in everyday work in photography and motion pictures. This has been augmented by friends and fellow-engineers and also enlarged to include terms on related topics. He does not claim completeness, but expects the book to be useful to readers of foreign technical literature, to photographic and motion-picture technicians and engineers, students, amateurs and dealers.

Americanisms are indicated as such in the English listing. These are surprisingly rare, considering the American weakness for jargon. Some examples are "sound recorders," "second cameraman" (which seem relatively colorless), and "tweeter" (which sounds more characteristic).

Of course in a work of this kind no one ever fully agrees with an author either on the choice of terms to be listed, or on their exact equivalents in the various languages. To this reviewer it seems that it might have been more profitable to extend more significantly into the auxiliary fields, say of visual optics, photometry and television, and less into such things as "tax," "hydrant," "music, Turkish," "paper cylinder" and "woman's voice."

On the matter of equivalence, confusion may be suspected in the translation of both "focal length" and "focus, depth of" by "Brennweite" and "distance focale." An understandable translation is given to the cross-listing "depth of focus" as "Tiefen-

schärfe" and "profondeur de netteté". Some confusion also appears in translating "H-type network (balanced)" as "circuit correcteur non balancé," and "T-type network (unbalanced)" as "circuit correcteur balancé." One wonders also if "to dub" can be rendered as *both* "doubeln" (and "doubler"), and "kopien" (and "contretyper"). "Dupe-film" appears understandably as "Dup-Film" and "film pour contretypage." Again, "efficiency, filament" is rendered "consommation d'une lampe électrique," where, if anything, the quantities are related inversely. These are a few examples of a number of puzzling translations.

In spite of these occasional idiosyncrasies, which really bulk very small in the total volume, the dictionary should be of great value to one who has much foreign technical reading (or perhaps writing) to do in these languages.—*Pierre Mertz*, Consultant, 66 Leamington St., Lido, Long Beach, L.I., N.Y.

An Introduction to the Theory of Random Signals and Noise

By Wilbur B. Davenport, Jr., and William L. Root. Published (1958) by McGraw-Hill Book Co., 330 W. 42 St., New York 36. 393 pp. (including bibliography and index). Illus. 6 by 9 in. Price $10.00.

The term "noise" was early introduced by telephone engineers to designate electrical interference turned into acoustic noise heard by the listener. It was then extended to mean erratic electrical interference into other communications systems, with interpretation by varied receivers. One such is a television image, seen by the viewer. More recently the work of Higgins, Schade, Blanc-La Pierre and others has indicated the same concepts to be utilizable in the evaluation of the optical images themselves, with or without electrical signals. A basic knowledge of the statistical techniques for evaluating noise and for distinguishing signal or pictorial information from it is therefore becoming of very wide application. To be fair with the present book, however, it deals specifically only with electrical signals, and extension to these further areas would really be the task of the reader.

The particular objective of the book is reached in its long last chapter, "Statistical Detection of Signals." This covers modern techniques and principles for the evaluation of significant information from a signal which is impaired by a variety of erratic corrupting influences, principally by additive random noise.

The three chapters which precede deal with the methods and design of physical aids which can be employed in separating the useful signal from the noise, namely linear filters (of Wiener and others) and nonlinear devices of various kinds.

All of the ten chapters before this point cover mathematical (and some electronic) background to prepare the reader for the tasks of the final four. The subjects include probability, random variables, probability distributions, averages, sampling, spectral analysis, shot noise, the Gaussian process, linear-system analysis, and the noise figure.

Two appendixes cover special mathematical discussions of the impulse function and integral equations. An extensive bibliography is presented.

The book was originally written for teaching purposes. It is, however, also useful to the engineer who must deal with noise and image granularity. Quoting from the jacket, "The chief departure in treatment is the replacing of various *ad hoc* methods of treating random signals and noise by a *consistent set of methods from the theory of random processes*." The authors have gone to great effort to make the subject clear and intelligible, not only by including the extensive background already noted, but by using obvious care in the arrangement and wording of the presentation. Nevertheless this is still a complex subject, and the engineer who can solve his noise problems by straightforward procedure all the way through will probably be rather rare. It is more likely, especially in fringe areas of the field, that he will use the development to establish some heuristic background from which he will work informally.

One criticism must be made — the use of the book for reference will be handicapped by an inadequate index. To give casual examples, about a page and a half of descriptive text on the Jacobian function does not appear in the index. Parseval's theorem is enounced, and the Rayleigh probability density function is derived, but neither of these names appears in the index.

To conclude, the material discussed in the book is becoming of increasing importance in the treatment of noise and image granularity, and the background presentation given on it is becoming more and more essential to the well-rounded engineer.—*Pierre Mertz*, Consultant, 66 Leamington St., Lido, Long Beach, L.I., N.Y.

The Transistor, 1948-1958

The June 1958 Bell Laboratories Record, a special issue. Published by Bell Telephone Laboratories Inc., 463 West St., New York 14. 48 pp. Price 35 cents.

Commemorating the tenth anniversary of the invention of the transistor, this special issue has ten articles which cover such highlights as: (1) Dr. M. J. Kelly, President of Bell Telephone Laboratories, states why the transistor is causing major changes in communications research and development, p. 190 (Issue's pages are 189-236). (2) Earth satellite transistors, developed at Bell Laboratories, are in both *Vanguard* and *Explorer*, p. 204. (3) Transistors now a 69-million dollar industry; dollar volume expected to exceed vacuum tubes by 1965, p. 205. (4) Electronic switching, now under study, may use large numbers of transistors, p. 215. (5) Automation is key to cost problem; Western Electric is solving many of the basic problems, p. 228. (6) The future? Transistorized electronic devices have wide applications in telephone plants, p. 233.

The papers and authors besides the introduction by Dr. Kelly are:

Semiconductor Research, Morgan Sparks
Research in Circuits and Systems, R. L. Wallace, Jr.
Transistor Designs: The First Decade, W. J. Pietenpol

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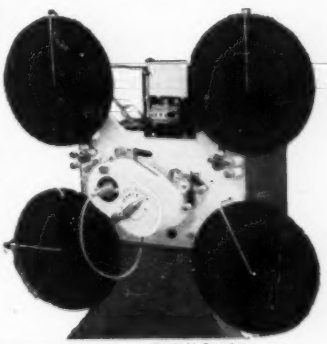

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The Reproduction of Colour

By R. W. G. Hunt. Published (1957) by Fountain Press, London; distr. in U.S. by The Macmillan Co., 60 Fifth Ave., New York 11. 208 pp. Illus. (16 in color). 6½ by 8½-in. Price $12.75.

To this reviewer the appearance of Dr. Hunt's book was a godsend. As a text for teaching an introductory course on photographic color reproduction it has no equal. Yet it has shortcomings which will be discussed later.

"The reproduction of colour," states Dr. Hunt, "is a fascinating subject; it involves physiology, psychology, physics, chemistry, and technology; it presents complexities which seem well nigh unfathomable; it involves a wide variety of industrial enterprises; yet its climax is an event of the utmost commonplace, looking at pictures." All the areas mentioned in this prefatory statement are touched upon by Dr. Hunt in his book, but emphasis is put on "color physics," to use a rather meaningless expression.

To give a general picture of the contents of Hunt's book, the practice of most reviewers can be followed by listing the chapter titles: Physical Colour Reproduction; Trichromatic Colour Reproduction and the Additive Principle; Additive Methods; The Subtractive Principle; Subtractive Methods in Colour Photography; Visual Appreciation; Some Problems in Colour Photography; The Colour Triangle; Colour Standards and Calculations; Colour Correction by Masking; Three and Four Colour Half-Tone Printing; The Transmission of Colour Television; Light Sources; and Assessing the Final Result.

From an instructor's standpoint the subjects included are all quite appropriate. But, considered as a basic reference work, several chapters, particularly the first three, could have been boiled down to about half the number of pages. Many existing books adequately cover the topics presented by Dr. Hunt in these sections.

This book is not the "how-to-do-it" type. It deals primarily with the *fundamentals* of color reproduction, including photographic, photochemical and television systems. In a sense, the book is a broad, technical review of the subject But a review that requires for understanding a considerable amount of prior knowledge.

Dr. Hunt's reputation in the field of color theory, and his position in the Kodak Ltd. Research Laboratories, might lead readers to believe that everything he states is beyond question. However, this reviewer found Hunt's discussions on some aspects of color reproduction less disciplined than those which have been presented by certain of his contemporaries. Evans, Hanson and Brewer, for example, in their book on the principles of color photography, were more cautious generally, and considerably more fussy about points of detail. A few examples will bear out this criticism, but these should not be regarded as a condemnation of the book. The book *is* a worthwhile contribution, and well deserving a place on one's library shelf.

Hunt's statement on p. 13 that Maxwell demonstrated "for the first time trichromatic colour reproduction" ignores the much earlier practical demonstrations of Jakob Christoffel Le Blon. Le Blon's *Coloritto*, and the commercial production of three-color reproductions produced by the method he disclosed (early 1700's), robs Maxwell of any basic claim to the discovery of trichromatic color reproduction, per se. (Possibly the fact that Le Blon — German by birth — failed financially after organizing a mechanical color print reproduction factory in Chelsea, England, has something to do with his lack of recognition by most English authors.)

Dr. Hunt's references (pp. 23, 51, etc.) to neutrals as "colorless" are inconsistent with other discussions in his book, and inaccurate. An object that one perceives as hueless is not considered colorless. If I were asked, for example, the *color* of my telephone, I should not hesitate to reply, "black." It would be absurd to say that it was "colorless" and then describe its low reflectance properties in an attempt to convey the fact that it is not white or gray.

The distinction of additive and subtractive color reproduction processes is not made clear. On p. 35 reference is made to the subtractive principle being used in the printing industry; on p. 142 it is stated that an integral tripack color material exhibiting a granular image structure is partly additive; on p. 143 it is said — although incorrectly — that gravure color printing tends to be truly subtractive, whereas letterpress and lithographic color printing represent a cross between a subtractive and a mosaic (additive) process. A student, without proper guidance, would not gain from such statements the fundamental difference between additive and subtractive color reproduction principles.

Finally, Dr. Hunt's unqualified acceptance of the retinal tri-receptor theory of color vision should not be taken for gospel. —*Lloyd E. Varden*, Columbia University, New York, N.Y.

Posing Patterns

By L. E. Broome. A Focal Press Book, published (1958) by Hastings House Publishers, Inc., 151 East 50 St., New York 22. 199 pp. incl. 1226 illus. 6¾ by 9¼ in. Price $10.00.

Animals in Motion

By Eadweard Muybridge. Published (1957) by Dover Publications, Inc., 920 Broadway, New York 10. 416 pp. incl. 340 pp. plates (with about 4000 individual photographs). 8 by 10¾ in. Price $10.00.

The bibliographical data speak for each of these richly illustrated books. Receipt of *Posing Patterns* has reminded us that *Animals in Motion* has until now been neglected in these columns. The highly commendable publishing service of Muybridge's *The Human Figure in Motion* was noticed in the *Journal* in September 1956.

Muybridge's eleven-volume work *Animal Locomotion* was published in 1887, and from it the present volume of plates has been

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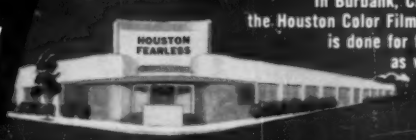

*In Burbank, California, Houston Fearless operates the Houston Color Film Laboratory where finest quality processing is done for the major motion picture studios as well as 16mm producers.

selected to make an inspiring and instructive reference. Typical actions of 34 different animals and birds are depicted. One favorite is Plate 99: Sow Trotting — a study of mixed comic motion and dignified intent.

Posing Patterns is described by the publisher as a dictionary of posing and poses for creative (still) photography but over a thousand illustrations can hardly sustain the label of stereotypes, even if they are intended to be; and such a collection of illustrations cannot but repeatedly remind us of motion up to, and after, the still pose. If the motion-picture maker does not already have his own clipping collection, in mind if not in file drawers, this book may become his "swipe" file. It has diagrams and explanations as well as the many photographs.

As packages of stilled motion the Muybridge books will continue to give animators, illustrators and other artists a hand up in their efforts to depict bodies into space in time.—*V.A.*

Psychological Effects of the "Western" Film: A Study in Television Viewing

By F. E. Emery and David Martin. Published (1957) by Dept. of Audio-Visual Aids, Univ. of Melbourne, Melbourne, Australia. 47 pp. 9 by 5¾ in. Paperbound. Price 2s.6d.

The first of a series of studies in mass-communication, this volume examines the effects of a Western, *The Lone Hand*, on a child audience, "to determine the nature of the psychological changes produced and further to determine which aspects of the film caused such change." One of the aims of the study in mass-communication, of which this book represents a part, is to find an answer to the question: "Will television lead to the deterioration of cultural standards or will it become a powerful civilizing influence, awakening a sense of greater social responsibility?" This book has a comprehensive bibliography. The book is highly recommended to those interested in the various aspects of television.—R.H.

International Screen Production Handbook, to be published by International Screen Production, Inc., 507 Fifth Ave., New York 17 (tentative publication date, Sept. 1, 1958), is a combination directory and working manual containing information for producers, sponsors, directors and others interested in TV film production. Among other categories of information, the *Handbook* will include concrete civic and labor information on each of 24 producing centers in the United States, 4 in Canada and 1 each in Cuba, Mexico and Puerto Rico. The information will include working rules and wage scales for all production crafts and performers in each center, descriptions of location sites and names of authorities from whom photographic permits and police assistance are obtained. Classifications range from Accounting Services to Writers. John E. Allen is General Manager of the enterprise, and Editor-in-Chief is Charles W. Curran.

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current literature

The Editors present for convenient reference a list of articles dealing with subjects cognate to motion-picture engineering published in a number of selected journals. Photostatic or microfilm copies of articles in magazines that are available may be obtained from The Library of Congress, Washington, D.C., or from the New York Public Library, New York, N.Y., at prevailing rates.

American Cinematographer vol. 39, July, 1958

Expert Photography Lends Production Value to Ford Commercials (p. 428) *J. Forbes*

Sound Dubbing—A Specialized Recording Technique (p. 432) *B. Weatherford*

Animated Film Techniques (p. 434) *C. Fallberg*

Filming the Blast at Ripple Rock (p. 438) *R. A. Francis*

vol. 39, Aug. 1958

Animated Film Techniques. Pt. II. (p. 488) *C. Fallberg*

Single-System Sound for the Arriflex "16" (p. 491) *J. Forbes*

Movie Systems in the Future (p. 492) *A. Mosby*

Fastest 35mm Film Processor (p. 494) *J. Henry*

Streamlining Production with "Picturized" Scripts (p. 496) *A. D. Roe*

vol. 39, Sept. 1958

Anamorphic Lenses (p. 522)

Animated Film Techniques. Pt. III. (p. 558) *C. Fallberg*

Underwater Cinematography (p. 560) *E. S. Woxholt*

A Camera Housing for Underwater Photography (p. 566) *J. V. Mascelli*

Exposure Evaluation (p. 564) *D. Norwood*

Audio vol. 42, July, 1958

Hearing, the Determining Factor for High-Fidelity Transmission. Pt. 1. (p. 24) *H. Fletcher* (Pts. 2 and 3 in Aug. and Sept., respectively) (Reprinted from Bell System Telephone Technical Monograph-B1351—Presented 1941)

vol. 42, Aug., 1958

Hearing, the Determining Factor for High-Fidelity Transmission. Pt. 2 (p. 45) *H. Fletcher*

vol. 42, Sept. 1958

Measurement of Amplifier Internal Impedance (p. 22) *W. H. Anderson*

Stereophonic Recording and Playback Amplifier (p. 24) *W. B. Denny*

Sound Reproducing Systems—Monaural, Binaural, Monophonic, and Stereophonic (p. 28) *H. F. Olson*

Hearing, the Determining Factor for High-Fidelity Transmission. Pt. 3. (p. 34) *H. Fletcher*

Bolex Reporter vol. 8, no. 3, Fall 1958

Three New H-Cameras (p. 8)

The Whys and Wherefores of Wide Screen Movies (p. 10)

British Journal of Radiology vol. 31, Sept. 1958

The Value of Cinematography in the Diagnosis of Malignant Strictures of the Oesophagus. (p. 465) *F. R. Berridge, D. McC. Gregg*

British Kinematography vol. 32, June, 1958

Driving Motors for Cine Projectors (p. 151) *Schofer*

vol. 33, July 1958

An Instantaneous Electronic Colour Film Analyzer (p. 3) *B. D. Loughlin*, et al. (Reprinted from *SMPTE Journal*, vol. 67, Jan. 1958, p. 17)

vol. 33, Aug. 1958

The Xenon Lamp in the Cinema (p. 35)

Operation of a Sound Transfer Suite for Television Films (p. 41) *J. K. Byers*

Overseas Film and Television Centre Film Training School (p. 43) *G. Pearson*

Film Daily vol. 114, no. 61, Pt. 2, 1958

Fortieth Anniversary Number Historical Highlights of the Motion Picture Industry (p. 141)

Film Technikum vol. 9, July, 1958

Stereophone Schall-Aufnahme und-Wiedergabe (p. 220)

International Projectionist vol. 33, Aug. 1958

The Problem of Shutter Flicker (p. 5) *R. A. Mitchell*

The Geneva Intermittent Movement: Its Construction and Action (p. 8) *A. C. Schroeder*

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Sprockets, Film Perforations and Triacetate Film Prints (p. 5)

The Problem of Shutter Flicker. Part 2. (p. 8) *R. A. Mitchell*

The Geneva Intermittent Movement: Its Construction and Action (p. 10) *A. C. Schroeder*

Kino-Technik vol. 12, Aug. 1958

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Der 16-mm-Umkehrfilm in der Praxis des Südwestfunks (p. 211) *O. Schulze*

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Die Lichttechnischen Eigenschaften der Perlux-Bildwand (p. 218) *H. Ritter*

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Hochfrequenzkinematographie mit dem Nyriatron (p. 249)

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DIN 50 37 Beiblatt Lichttechnische Bewertung von Scheinwerfern Film- und Fernseh-Scheinwerfer Nutzlichtbewertung (p. x)

Philips Technical Review vol. 19, No. 12, 1957/58

The Projection of Colour-Television Pictures (p. 338) *T. Poorter* and *F. W. de Vrijer*

Photo-Technik und -Wirtschaft no. 9, 1958

Photoanalyse mit Kurzzeitphotographie und Zeitdehnerfilm (p. 350) *Thorwart*

Kurzzeitphotostudien von Strömungsvorgängen (p. 354) *K.-W. Westphal*

Kurzzeitphotos vor der Düse einer Flammspritzpistole (p. 357) *D. Elle*

RCA Review vol. 19, Sept. 1958

Design and Development of the 21CYP22 21-Inch Glass Color Picture Tube (p. 334) *C. P. Smith, A. M. Morrell*, and *R. C. Demmy*

Tekhnika Kino i Televideniya, USSR no. 8, 1958

The Reproduction of Half-Tones in the Black-and-White Television Image (p. 9) *R. Ya. Brunova, A. G. Buryakov* and *V. M. Zusmanovich*

Typical Lay-Outs of Television Centers (p. 19) *I. I. Govallo* and *I. V. Ostrovskii*

Industrial Television Equipment (p. 27) *V. I. Sardyko*

A Method for the Determination of the Effective Relative Aperture of Cinematographic Objectives (p. 39) *V. G. Pell'*

Numbering Device for Simultaneous Synchronous Numbering of Picture Film and Sound Track (p. 57) *M. F. Ottochek* and *N. N. Ogurtsov*

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The A. P. Dovshenko Art-Film Studios of Kiev (p. 1) *V. Tryc'ko*

Electronic Image Intensification (p. 10) *A. M. Khalfin*

A Studio Camera for Colour Television with Flying-Spot Scanning (p. 19) *N. I. Dushkevich* and *L. T. Perevesentsev*

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A Method of Determining the Vertical Resolving Power and Aperture Characteristics of a Television Display Tube (p. 42) *M. V. Antipin*

A Method of Calculating a Condenser with Spherical Surfaces for Cinematograph Projectors with Incandescent Lamps (p. 49) *V. V. Petrov*

A Machine for Coating Ferromagnetic Suspensions on Cine Film (p. 57) *K. Kh. Sutyushev* and *M. B. Khalameiser*

A Small Device for the Collection of Silver from Wash Water (p. 72) *E. A. Iofis* and *B. P. Chernyavskii*

Cinematography in Czechoslovakia (p. 75) *F. Pilat*

SMPTE Test Films

Test films planned by the Society's technical committees and produced under the Society's exact supervision are available from the headquarters office at 55 West 42 St., New York 36. Catalogs containing brief descriptions of each film are obtainable on request.

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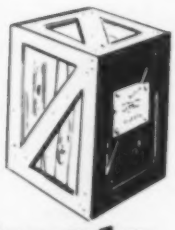

new products

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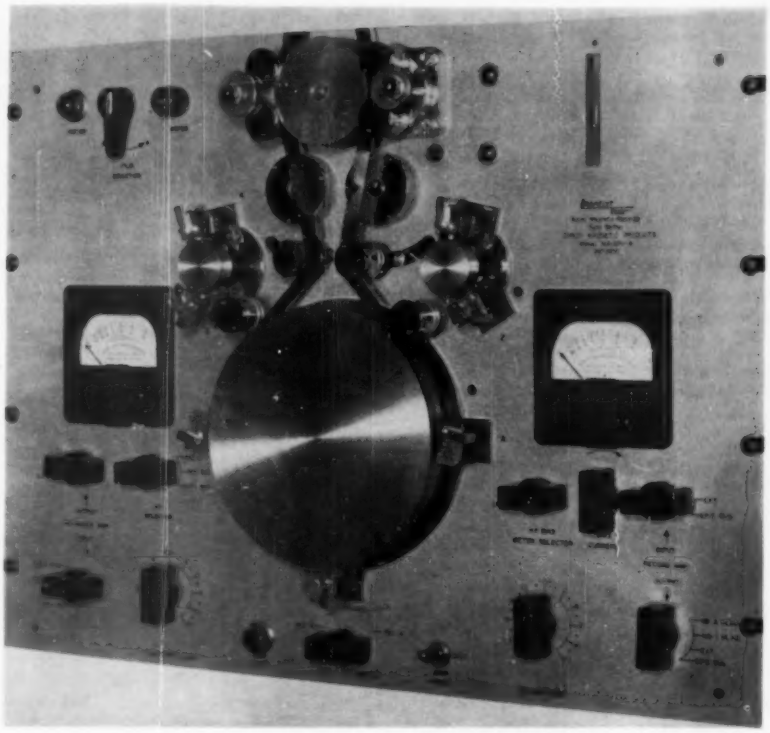
Further information about these items can be obtained direct from the addresses given. As in the case of technical papers, the Society is not responsible for manufacturers' statements, and publication of these items does not constitute endorsement of the products or services.



A magnetic recorder designed to make editing sound motion-picture negatives as precise and simple an operation as the editing of magnetic tape has been announced by D'Arcy Magnetic Products, Ogden Dunes, Gary, Ind. The device has been named the Rap-Edit Sync Point Shifter Magnetic Recorder. It requires only one operation to relocate the recorded words of a single-system magnetic sound record to a point directly adjacent to their mating picture (editorial sync). The recorder is expected to be especially useful to producers of TV newsreels, educational and documentary films. It will also record 200-mil standard magnetic track and 50-mil displaced stereo magnetic track.

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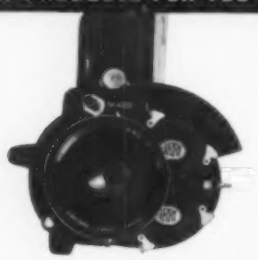

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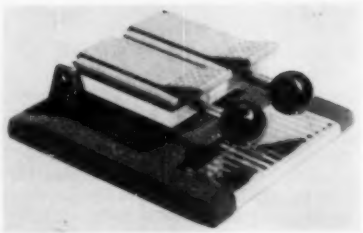

The Studio Quik Splicer, manufactured by Hudson Photographic Industries Inc is distributed by S.O.S. Cinema Supply Corp., 602 W. 52 St., New York 19, and 6331 Hollywood Blvd., Hollywood 28. The unit is designed for splicing 16mm and 35mm film as well as magnetic tape and is designed for use with all types of film base as well as optical or magnetic soundtracks. Components are nonmagnetic (of cast bronze and nonmagnetic steel). In making the splice, a special Mylar tape, called Quik-Splice, is applied which, reportedly, will not dry out or shrink and is unaffected by common film cleaning agents. The tape is pre-cut to the correct size and is paper-backed. To make the splice, the operator positions the splice patch over the aligning pins and strips off the protective covering. The splicer is priced at $79.50 and splicing tape is available at a price of $5.00 for a package containing 250 splices. A sample of the tape is available without charge from the distributor.

An electric automatic splicer capable of splicing digital tapes, paper, magnetic films and tapes has been announced by Prestoseal Mfg. Corp., 37–27 33 St., Long Island City, N.Y. Splicing is effected by the application of controlled heat and pressure and the use of cement, adhesive

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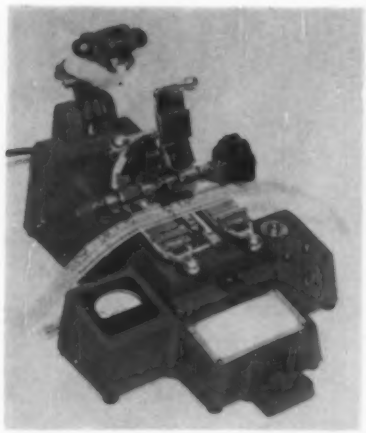
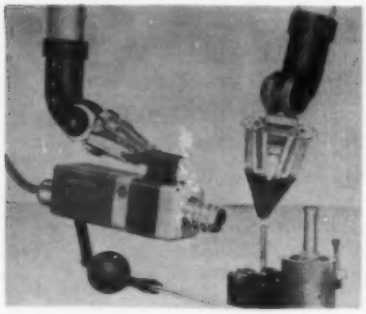


or glue is not required. The splicer is designed to handle all sizes of digital tapes. The 17-lb unit is 9 in. high, 11¼ in. wide and 17 in. long. It operates from a 110/120 v a-c source at 50 to 60 cycles. It is priced from $632.00.

The Fairchild Data Reader, a product of Fairchild Data Devices Corp., 580 Midland Ave., Yonkers, N. Y., has been designed to reduce photographic data to digital form for electrical transcription. It can be used for measuring photographic transparencies on plates, sheet film or roll film. X and Y ordinates are measured to a least count of 0.001 in. and angles to 0.1 degree. A specially designed analog-to-digital converter in the goniometer system gives display reading and electrical readout to a maximum quantity of 359.9°. Further rotation returns the reading to 0°. Overall accuracy of measurements is reported to be ±0.005 in.



The Spectra, reported to be the world's smallest high-definition TV camera, has been announced by Photo Research Corp., 837 N. Cahuenga Blvd., Hollywood 38. The 2.5-lb camera is 2.6 in. square with a length of 7.5 in. The equipment has been tested to 20 g in temperatures of 70 C and altitudes of 60,000 ft. It feeds a 600-line image through its 10-mc video amplifier to a 14-in. monitor to allow a film to be made of the monitor screen for further evaluation. The camera does not use transistors because of possible deterioration caused by radiation when close-up studies are made in laboratories engaged in atomic research.

The Navy's powerful icebreakers will be aided in their sometimes dangerous tasks by low-flying, remote-controlled helicopters fitted with TV cameras to photograph ice conditions. TV monitors on the ship's bridge and in the combat information center enable observers to study ice conditions ahead. Equipment used in the first try-out was developed by the Government and Industrial Div. of Philco Corp. and included a UHF video transmitter operating in the 780–900-mc frequency range up to a distance of 35 miles and an industrial TV camera fitted with a wide-angle lens. The icebreaker which participated in the experiment was the *USS Glacier*.

A "light chopper" which can produce pulses of light only a few billionths of a second in duration has been developed by scientists working in the Westinghouse Research Laboratories, Pittsburgh 35. The device is also used to produce ultrafast pulses of infrared and ultraviolet radiation.

Principles and applications of the "light chopping" system are described in a paper by M. Garbuny, T. P. Vogl and J. R. Hansen published in the Oct. 1957 issue of the *Review of Scientific Instruments*. The article describes the method as consisting of "surrounding a rotating multisided mirror by a set of stationary mirrors. The assembly is so adjusted that the collimated light from the source is repeatedly reflected between the central and the stationary mirror planes."

An improved version of the ¾-in., 150-w lamp for 8 mm motion-picture projectors introduced earlier this year (*Journal*, Feb. 1958, p. 120) has been announced by Sylvania Electric Products Inc., 1740 Broadway, New York 19. In the new lamp (called the Super Tru-Flector) the light-focusing reflector is supplemented by a thick, closely compacted coiled coil-filament and a small low-voltage transformer to permit greater control over lighting characteristics. The new lamp is priced at $5.00.

Coal mine interiors, caves, windows, doors, walls, trees and pillars and many other objects and structures used on motion-picture sets are made in a vacuum forming machine manufactured by Auto-Vac Co., 1984 State St. Extension, Bridgeport, Conn.

One of these was purchased several months ago by CBS-TV for use in its Production Dept. The machine, reported to be the largest of its kind in the world, will produce in plastic almost any form the dimensions of which are equal to or less than 12 ft long, 6 ft wide and 2 ft deep. For the coal mine interior, 40 panels of polyvinyl chloride were used. Bits of Styrofoam, wood and rags were added to the basic mold to make a random pattern simulating the lumpy look of a coal mine. At the conclusion of the coal mine drama the panels were painted and curved to become a realistic cavern.

One of the main advantages of the vacuum forming process is the saving of time and money and set construction. For example, the machine can make double hung plastic windows that can be opened or closed like "real" windows, or it can make dummy windows with open or solid "glass" areas. When needed, scenery can be painted on the plastic panes, or blank pane areas can be formed where action takes place on the other side of the set. The plastic windows are mounted on wood frames which can be nailed into flats wherever needed, eliminating the need for extra flats containing built-in windows. Other props made by this process have included pillars, mirror and picture frames, rows of books, railroad rails, pediments, tree bark, statues, rocks and other oddments.

These notices are published for the service of the membership and the field. They are inserted three months, at no charge to the member. The Society's address cannot be used for replies.

Positions Wanted

Photographic and Optical Engineer. Member of technical staff Bell Telephone Labs 21 yrs; Wollensak Optical Co. 4½ yrs; Fairchild Camera & Instrument Co. 3½ yrs. Familiar with practically every phase of engineering photography. Established primary techniques for complete photographic systems including film processing. Designed high-speed motion-picture and recording cameras. Developed new techniques for use in underwater, aerial, missile, industrial and research problems of motion analysis. Can lecture, sell. Author numerous publications and *Photographic Motion Analysis* (Industrial Laboratory Publishing). Served as consultant to many organizations. Fellow SMPTE and Royal Phot. Soc. Founded SMPTE High-Speed Committee and organized first International High-Speed Congress. Salary open. Will relocate. John H. Waddell, 33 Loretta Dr., Syosset, L. I., N. Y. Tel: WAlnut 1-5469.

Engineer-Photographic. Extensive experience in design and development of military and consumer opto-electro-mechanicals, photographic products and instrumentation. Capable of assuming complete responsibility from creative inception to acceptable prototype. Experienced in manufacturing procedures, design simplicity and parts interchangeability. Seeking project assignment or part-time engagement. Write: R.V.N., 59 New York Ave., Westbury, L.I., N.Y.

Cameraman. Have Bolex H16 equipment; will travel. Age 32. 10 years experience news, travel films, wildlife, etc. Go anywhere, anytime. Jack M. Sullivan, Offtrail Films, P. O. Box 86/3904 Sockwell Blvd., Greenville, Texas. Tel: GLadstone 5 2679/5 1424. Send for Confidential Service Bulletin #4.

Motion-Picture Engineer. Available for new position February 20, 1959; will consider job in any part of the world. Now completing contract with Reevesound Co., New York, installing laboratory overseas. Formerly with Capital Film Labs, Washington, D.C., for several years. Have designed and built lab equipment for a number of years for the trade (firm name in Washington, D.C., is Telex Films). Have the experience to do capable work in production, editing, sound or lab. Complete résumé upon request. Would prefer any new overseas assignment to start by March 10, 1959. Write airmail: Victor E. Patterson (USOM), American Embassy, APO 271, New York, N. Y.

Television Engineer. French citizen, 7 yrs experience TV research in Paris, subsequently engineering manager of TV station in Casablanca, Morocco, seeks position in United States or Mexico, preferably with an American company. Degrees in electrical and radio engineering. Age 34, married. Write: Lucien Chareyre, 37 rue de Mareuil, Casablanca, Morocco.

Cameraman-Editor experienced in all phases of film production, feature films, commercials, TV documentaries, sound recording and laboratory. Desire permanent position with production company or television station. Will work in studio and/or anywhere on location. Knowledge of French, Italian and Arabic. Write to A. P. Mamo, 7945 Cartier Street, Montreal, Quebec, Canada.

Motion-Picture Production. Experienced in film production, studio and location, educational, industrial and TV films. 15 years in industrial films, 6 years producing TV commercials. Seeking a position as production executive with a commercial or industrial motion-picture unit. Experienced in various phases of film production; operated most 35mm and 16mm cameras, directed industrial films, produced TV commercials. Excellent references. Résumé on request. Write: Edw. A. "Jack" Price, 2417 Crest Ave., South Bend 14, Indiana.

Educator - Cameraman - Producer. Available every summer for either industry or education. Experienced in educational films, TV commercials, public relations films, newsreel work and live educational television. Degrees: B.S. in Ed., M.A. Interested either in production or organization, setting up program and teaching others to carry on. Also interested in any type of employment in motion-picture industry for which qualified. Experienced in every technical phase of motion-picture production. Own complete production equipment, cameras, sound, lights etc. Age 42. Teacher in winter. Available from June 12 to Labor Day. Salary open. Henry E. Eisenkramer, 7550 Washington Ave., University City 5, Mo. VOlunteer 3-5669.

Chemistry and Chemical Physics. Director of Research and Experimental Engineering for 20 yrs, predecessor of Harris Intertype Corp.; over 70 patents and applications in photographic and photomechanical fields; member many scientific organizations. Special interests: light sensitive substances, developers, phototypesetting, highspeed data recording, photopolymerization. Overseas contacts in research and development. Available full time or on a consulting basis. Would relocate. William H. Wood, Route 1, Box O, Rockbridge, Ohio.

Motion-Picture Writer, Director or Unit Manager with some TV experience returning from 8 yrs work in Middle East. B.A., M.A. in Cinema from USC. Wants position with vigorous film or television company. Have family, will relocate. Résumé on request. Write: John H. Humphrey, Apt. 604 West, 74-10 35th Ave., Jackson Heights, N. Y.

Photographic Administrative and Technical Specialist. 21 yrs experience in laboratory administration, sales administration, selling, quality control, personnel supervision, camera work and production. Heavy experience in color with leading laboratory. Seeking connection in administrative capacity with major TV or film company. Detailed resume on request. Willing to relocate. Robin R. Lewis, 4 Arbor Rd., Syosset, N. Y. WAlnut 1-0063.

Positions Available

Cameramen. Staff position. References and resume of experience required. Confidential. **Sound Technicians.** Experience, references. Permanent position. **Laboratory Technicians.** Timing experience. Permanent position. Write: I. C., 423 East 90 St., New York 28.

Electronic Engineer (Television Division). Qualifications: Engineering degree or equivalent; 3 yr general electronics and 1 yr television experience; extensive knowledge of vidicon and image orthicon monochrome and color systems, broadcast and closed-circuit systems, kinescope and video tape recording techniques and equipment, and microwave transmitting and receiving video and audio equipment. The incumbent of this position plans, designs, advises upon, coordinates, tests and evaluates development of television equipment, systems and facilities to determine their application in military service. Salary $10,130 per annum. Contact Miss Mary Jane Kerwin, Personnel Management Branch, Civilian Personnel Office, Army Pictorial Center, 35-11 35th Ave., Long Island City 1, N. Y. Tel: RAvenswood 6-2000, ext. 238.

Television Engineers. Positions available for television engineers meeting the following minimum requirements: (a) BS degree with a minimum of 1 yr of TV equipment design on camera equipment, broadcast or industrial systems; or (b) 4 yrs experience on television design work in lieu of BS degree with 1 yr spent on television camera design. Young and expanding company located in smog-free Orange County, close to beaches and downtown Los Angeles. Excellent living conditions. Salary dependent upon experience and education. Send complete resume to Personnel Dept., Interstate Electronics Corp., 707 E. Vermont Ave., Anaheim, Calif.

HOLLYWOOD FILM COMPANY

MAIN OFFICE: 956 N. SEWARD ST., HOLLYWOOD (38), CALIFORNIA • HO. 2-3284
BRANCH OFFICE: 524 WEST 43RD ST., NEW YORK (19), NEW YORK • LO. 3-1546

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Meeting Calendar

American Physical Society, Nov. 28–29, U. of Chicago & Hotel Windermere, Chicago.

ASME, Annual Meeting, Nov. 30–Dec. 5, Hotel Statler and Hotel Sheraton-McAlpin, New York

Electronic Industries Association, Conference on Reliable Electrical Connections, Dec. 2–4, Statler-Hilton Hotel, Dallas, Texas.

American Institute of Chemical Engineers, Annual Meeting, Dec. 7–10, Netherland Plaza Hotel, Cincinnati, Ohio.

American Association for the Advancement of Science, Annual Meeting, Dec. 26–31, Sheraton-Park Hotel, Washington, D. C.

IRE, AIEE, EIA, American Society for Quality Control, National Symposium on Reliability and Quality Control, Jan. 12–14, 1959, Bellevue-Stratford Hotel, Philadelphia.

Institute of the Aeronautical Sciences, Annual Meeting, Jan. 26–29, 1959, Astor Hotel, New York.

Society of Plastics Engineers, Annual Meeting, Jan. 27–30, 1959, Commodore Hotel, New York.

American Physical Society, Annual Meeting, Jan. 28–31, 1959, New Yorker Hotel, New York.

85th Semiannual Convention of the SMPTE including International Equipment Exhibit, May 4-8, 1959, Fontainebleau, Miami Beach.

86th Semiannual Convention of the SMPTE including Equipment Exhibit, Oct. 5-9, Statler, New York.

87th Semiannual Convention of the SMPTE, May 1-7, 1960, Ambassador Hotel, Los Angeles.

88th Semiannual Convention of the SMPTE, Fall, 1960, Shoreham Hotel, Washington, D. C.

89th Semiannual Convention of the SMPTE, Spring, 1961, Royal York, Toronto.

90th Semiannual Convention of the SMPTE, Oct. 15-20, 1961, Statler, New York.

Journals Available/Wanted

These notices are published as a service to expedite disposal and acquisition of out-of-print Journals. Please write direct to the persons and addresses listed.

Available

Issues beginning in 1953 available on a nominal basis. Write: Mitchell M. Badler, 1711 Davidson Ave., Bronx 53, N. Y.

Complete set of Transactions, except Nos. 6 and 9, and all Journals published to date, including indexes. All in good condition. Price $500. W. W. Hennessy, RFD #2, Pound Ridge, N. Y.

Complete set of Journals from May 1937 to June 1954, including special volumes and membership directories, excellent condition; also Mar., May 1934 and July 1935 issues. Write: Harry R. Lubcke, 2443 Creston Way, Hollywood 28, Calif. HO 9-3266.

Jan.–Dec. 1950; Jan., Feb., Apr.–Dec. 1951; Jan.–Mar. 1952. Also available are vols. 6 and 7 of The Television Society (British) covering the period Jan. 1950 through Sept. 1955. Write: Andrew N. McClellan, 65 Hillside Drive, Toronto 6, Ont., Canada.

Dec. 1946, Feb.–Dec. 1947, 1948–1955 complete. All copies in perfect condition; for sale as entire lot only. Write: Joseph W. MacDonald, 2414 Sullivant Ave., Columbus 4, Ohio.

Jan. 1947 to Dec. 1957 complete and in perfect condition. For sale only as a set. Write; Charles J. Marshall, 2816 Royalston Ave., Kettering 19, Ohio.

Complete set of Journals Jan. 1949 to Dec. 1958. Perfect condition. What offers? Write: J. G. Jackson, 210 Kingsway South, Port Alberni, B.C., Canada.

All Journals June 1940 to Oct. 1958, except Aug. 1943, Jan., May, Nov. 1946, Dec. 1953. Write: David Waddell, 95 North St., Stoneham 80, Mass.

Wanted

Jan. 1938. E. Raymond Arn, Film Associates, Inc., 4600 S. Dixie Ave., Dayton 9, Ohio.

High-Speed Photography, Vols. 2 & 3. Morton Sultanoff, Terminal Ballistics Laboratory, Aberdeen Proving Ground, Md.

High-Speed Photography, Vols. 1, 2 & 3. John H. Waddell, Fairchild Camera & Instrument Co., 5 Aerial Way, Syosset, N. Y.

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  CBS Television Network; CBS Television Stations; CBS News; CBS Film Sales; Terrytoons
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Du Art Film Laboratories, Inc.
  Tri Art Color Corporation
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Dynamic Films, Inc.
Eastern Effects, Inc.
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Houston Fearless Company
Hunt's Theatres
JM Developments, Inc.
The Jam Handy Organization, Inc.
Jamieson Film Co.
The Kalart Company, Inc.
  Victor Animatograph Corporation
Kling Photo Corp. (ARRI Div.)
Kollmorgen Optical Corporation
Lorraine Orlux Carbons
J. A. Maurer, Inc.
  Precision Film Laboratories, Inc.
Mecca Film Laboratories, Inc.
Mitchell Camera Corporation
Mole-Richardson Co.
Motiograph, Inc.
Motion Picture Association of America, Inc.
  Allied Artists Products, Inc.
  Columbia Pictures Corporation
  Loew's Inc.
  Paramount Pictures Corporation
  RKO Radio Pictures, Inc.
  Twentieth Century-Fox Film Corp.
  United Artists Corporation
  Universal Pictures Company, Inc.
  Warner Bros. Pictures, Inc.
Motion Picture Printing Equipment Co.
Movielab Film Laboratories, Inc.
Moviola Manufacturing Co.
National Carbon Company, A Division of Union Carbide and Carbon Corporation
National Screen Service Corporation
National Theatre Amusement Co.
National Theatre Supply Company
Neighborhood Theatre, Inc.
Northwest Sound Service, Inc.
Panavision Incorporated
Pathé Laboratories, Inc.
Prestoseal Mfg. Corp.
Producers Service Co.
Radiant Manufacturing Corporation
Radio Corporation of America
Rank Precision Industries Ltd.
Reid H. Ray Film Industries, Inc.
Reeves Sound Studios, Inc.
Charles Ross, Inc.
S.O.S. Cinema Supply Corp.
Shelly Films Limited (Canada)
Southwest Film Laboratory, Inc.
The Strong Electric Company
Technicolor Corporation
Titra Film Laboratories, Inc.
Trans-Canada Films Ltd.
Van Praag Productions
Alexander F. Victor Enterprises, Inc.
Westinghouse Electric Corporation
Westrex Corporation
Wilding Picture Productions, Inc.
Wollensak Optical Company